THE McGRAW-HILL MAGAZINE FOR DESIGN ENGINEERS

NOV 13, 1961

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WIREWRAP

It provides a quick, strong, reliable, solderless joint. A report of ten years of experience plus a complete guide to best terminal design.

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PRODUCT ENGINEERING

ALUMINUM SCREWS

They offer more clamping force per in.-lb of torque, though breaking torque is lower than for other metals.

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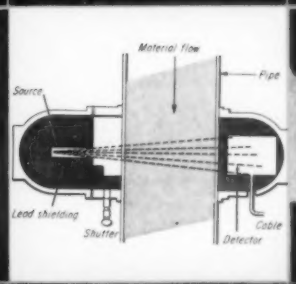
ISOTOPES



Dozens of new, and safe, design jobs for "activated atoms." Here's how they can be used to measure, weigh, test and power your product.

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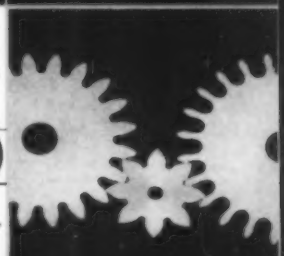
GEARS



These enlarged-tooth pinions may have as few as three teeth. And they're stronger and easier to make than ultrafine pitch gears.

PAGE 110

The world's largest line of air valves is also the most advanced because of the Ross engineering staff

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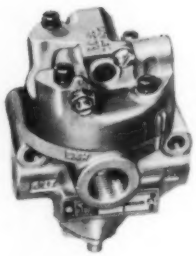

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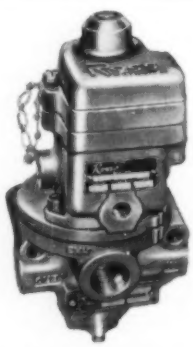

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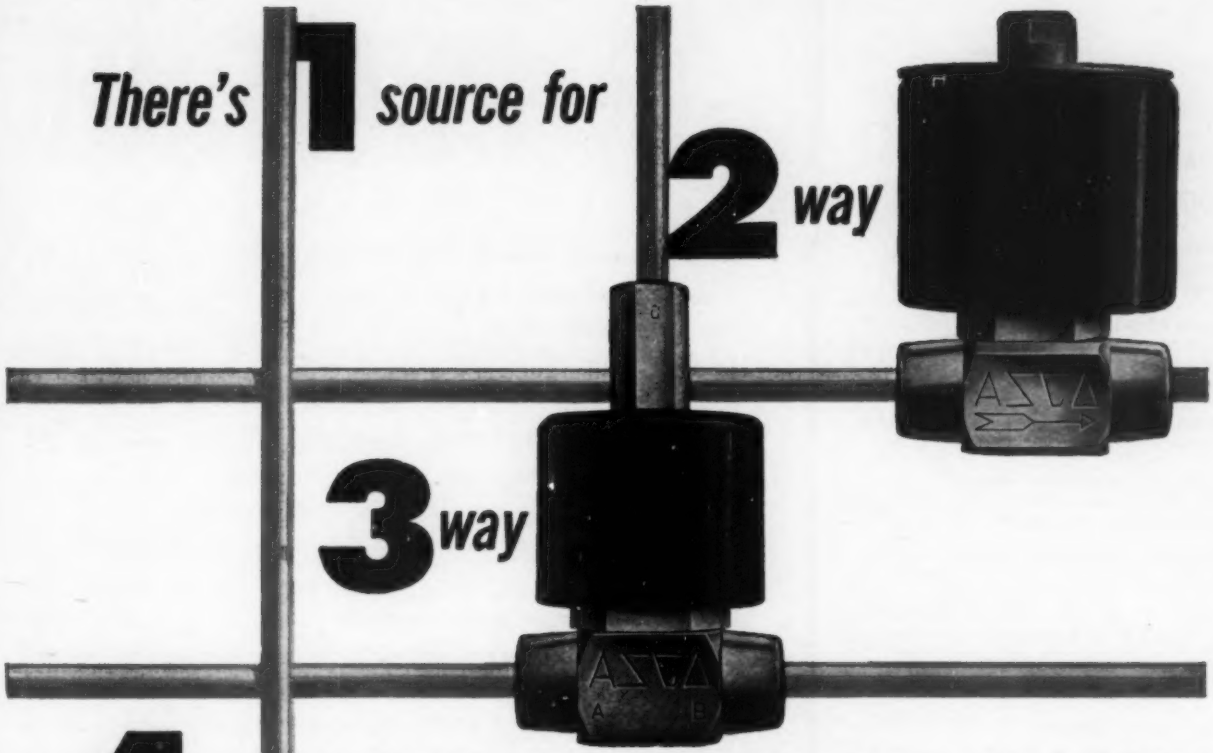
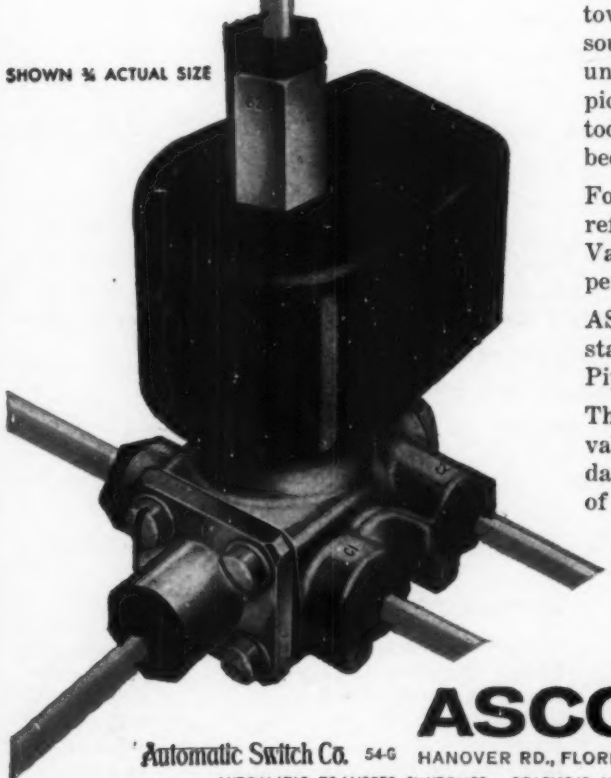


SHOWN ¾ ACTUAL SIZE



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These activated atoms are versatile indeed. See how they can determine wear, check assembly accuracy, weigh, measure and test. *Annesta R Gardner*

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For cost control

Graphical analysis shows where production control has gone wrong—and what to do about it.

Strength of screw threads

Table gives minimum tensile and shear areas for external and internal threads of all sizes, all classes.

Hermetic magnetic couplings

Recent tests suggest new modifications of the equations of torque transmission through a metal wall.

8 push-pull linkages

They're the input, output and motion transfer arrangements basic to all linkage devices.

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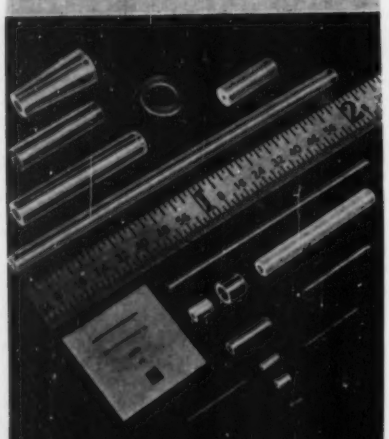

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HORIZONS

R. Haugerman

What's a "Junior Executive?"

Three ingrained ideas of Americans are ludicrous: That criticism is everyone's right and has sound basis in fact; that a bride is suddenly endowed with the ability to run a household; that the ability to manage descends upon a man like a prophet's cloak at the same time he is given a title.

Psychologists may say that griping is good for the ulcers—but it may cause ulcers in everybody around the griper. Criticism is properly a vertical function, not a horizontal or lateral one. The man who gripes neither relieves his own feelings (because griping does not cure the cause of the gripe) nor those of his fellows. Whether they agree with him or not, they are subjected to his disagreeable comments, to everybody's loss. Every modern benedict learns that the old-fashioned idea that mothers should train their daughters to run a house is as sound as the dollar used to be. And every man with a new title, who earns it, finds out that a natural aptitude for management must be supplemented by experience and thought.

We're concerned here only with the third of these cases—the young man who achieves his first supervisory title—the so-called "junior executive." Like the new bride, he has no training for his job unless he had a touch of cost accounting and personnel courses in engineering school.

What does the "new" or "beginning" management man do? His prime job is to take some of the load off his boss, to take responsibility for keeping his chief from stumbling and for supervising the work of his own subordinates. He does not go to his chief for jobs, but for approval of a planned course of action. He must clear the path for his men to work in, and bring out their best efforts to a common end. He must be able to attract, as well as develop, ideas, and to sort out from those available which should be implemented—then go ahead to implement them.

The basic requirement for any executive is the ability to handle people. This is more important than the ability to make decisions or the possession of technical knowledge. That's why so many engineers find problems with management, because our basic training and orientation is toward things and ideas rather than toward people.

You cannot instruct a man as you do a machine, or as the legendary army sergeant did. He barked a command and expected a reflex response. When the executive gives an instruction he wants intelligent reaction, which a bark never gets.

The ability to handle people is a part of the personality of an individual. Another ingredient of it is firmness of purpose. George Eliot wrote a speech for Rector Cadwallader in *Middlemarch* in which he says of the squire, "Brooke is a very good fellow, but pulpy; he will run into any mold, but he won't keep shape." It is vital that the executive have enough confidence in himself and enough firmness of purpose that he goes ahead and is certain he's right. He cannot comprise with the necessity for making decisions, yet he must also remember as Ralph Waldo Emerson wrote, "A foolish consistency is the hobgoblin of little minds."

Lastly, technical knowledge is helpful, but even more important is the ability to recognize technical competence of subordinates and to accept willingly their opinions and decisions when pertinent. No one else can

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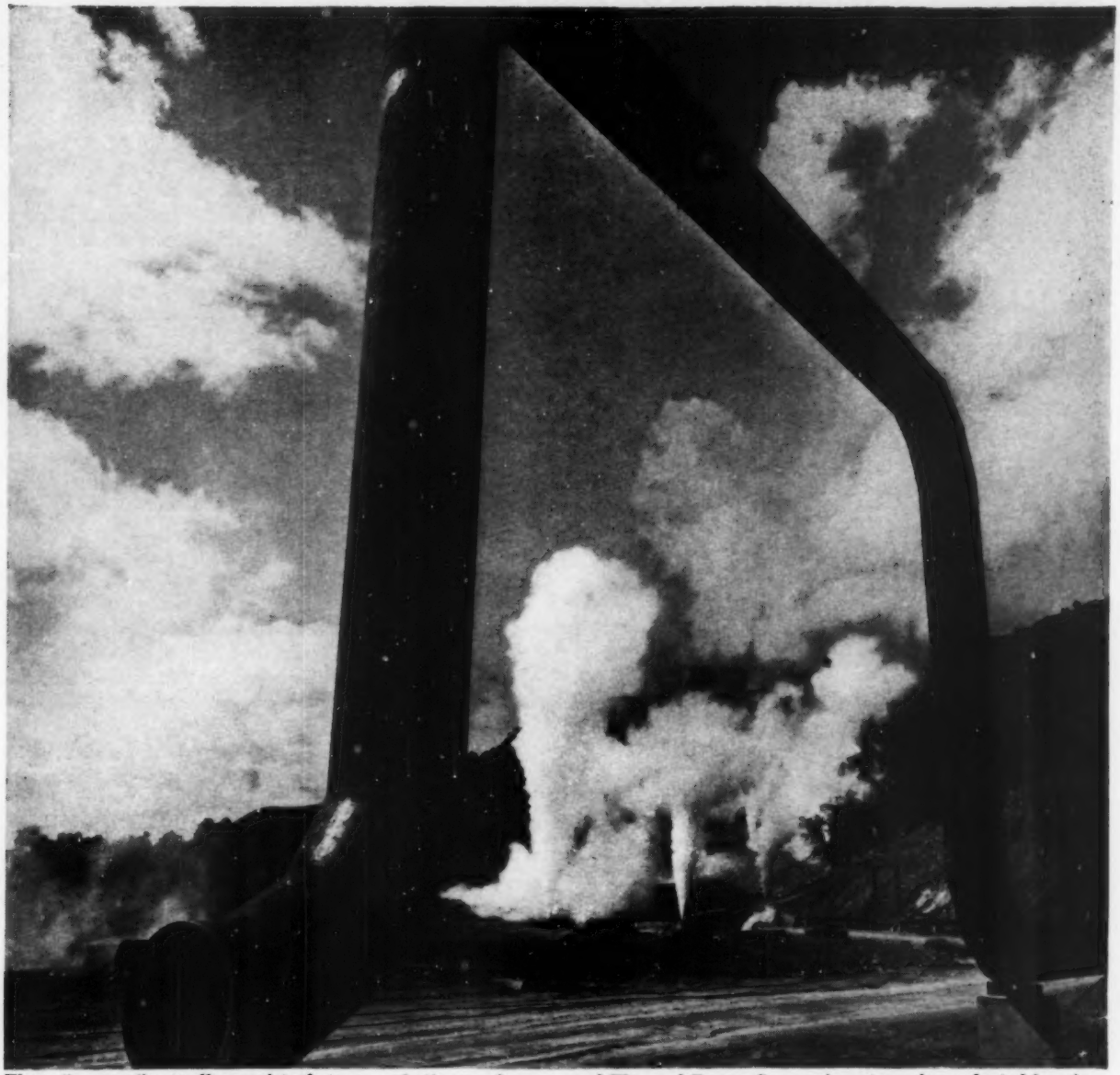

These "geysers" actually consist of steam rocketing up from deep in the ground. From this well area, operated by Magma and Thermal Power Companies, steam is conducted by pipeline to The Geysers Power Plant a quarter-mile away.

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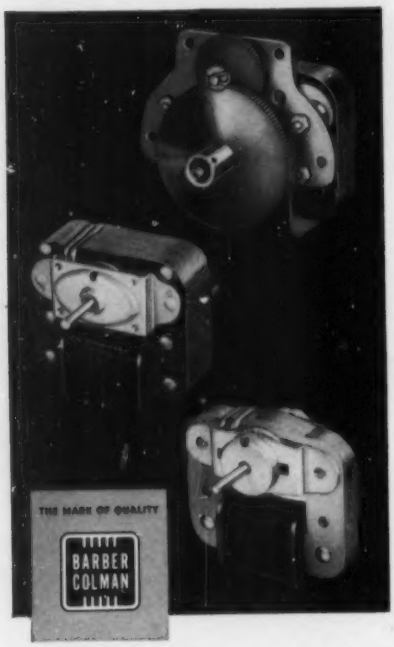

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HORIZONS *continued*

be expected to—or indeed should be permitted to—make the ultimate decision, but the ideas of the skilled specialist should be given their true weight when the decision is made. Frequently, the criticism of an executive is that he doesn't know as much as his subordinates. Such a criticism is not valid. He doesn't have to know as much as his subordinates, providing he knows how to use what they know for the betterment of the entire group. His job is not to be a specialist but a generalist, to be as much an idea user as he is an idea generator, and to maintain a mind that is open to change and suggestion, but fixed on the basic objectives.

Field Marshal von Hindenburg crushingly defeated the Russians at the Battle of the Tannenberg Marshes. It had been touch and go, so Hindenburg was a hero.

But was he? The story got 'round in military circles that the plan of battle—in every particular—had been devised by Hindenburg's chief of staff, Maj Gen Ludendorff. Opinion veered to the idea that Ludendorff was the real hero of Tannenberg.

But was he? Again the military-circle stories that the plan of battle—in every particular—had been devised by Capt Hauptmann of the Operations Section, General Staff. Hauptmann was the real hero of Tannenberg.

Years later, a lady (no one else would have dared) asked Hindenburg himself the truth of the matter. Who really had won at Tannenberg? Rumbled the old field marshal: "Madame, I do not know who won the Battle of Tannenberg. I only know who would have lost it."

You have heard the legends of who "*really* invented" the steam engine, steamboat, air brake, telephone, electric light, radio. There is always some factual basis for the story—but history pays off the man who selected—and achieved—the basic objective.

To pick one of the above situations at random, let's dig a little into the electric light. When Edison started his research, rivals were already installing blinding arc lights on streets, in railroad terminals, in stores. Each larger lamp was hailed as an achievement. But Edison began, not by emulating them, but by studying the sociology and economics of indoor illumination. He decided that the real need was small lights in many places, went on to select high voltage, low amperage, and high resistance as the parameters. In one short year he developed and produced a new kind of generator with low internal resistance, the parallel circuit, and at last the hardware—the filament and the bulb. He did this by making his greatest—and least-recognized—invention, the research team.

Here is the source of our modern engineering approach, the development that made the junior executive necessary in the first place.

• • • •

US research spending soared 95% between 1954 and 1958 ($5.2 billion to $10.1 billion), according to a new National Science Foundation report. But the number of professional R & D personnel increased only 50% (from 233,000 to 331,000). The difference, explains the report, is the result of three factors: increased volume of expensive consumable items, greater cost to buy and operate research equipment, rises in wages of scientists and engineers. Our private suspicion: There is increasing emphasis on the "D" rather than the "R." Figures we quoted two years ago of $25,000 per professional person per year seem to have risen above $30,000.

Colleges and universities showed an 82% increase in research personnel, industry 46%, but the largest *numerical* increase was in industry: about 75,000. Life sciences led with a gain of 72%; physical engineering came second with 52%. Distribution of personnel remained relatively unchanged: 70% industry, 10 to 15% colleges and government, only about 2% in nonprofit research outfits. Interesting is the report that over-all personnel increased 25% in the four years, but R & D personnel—those actually doing lab work—jumped nearly 50% in that time.

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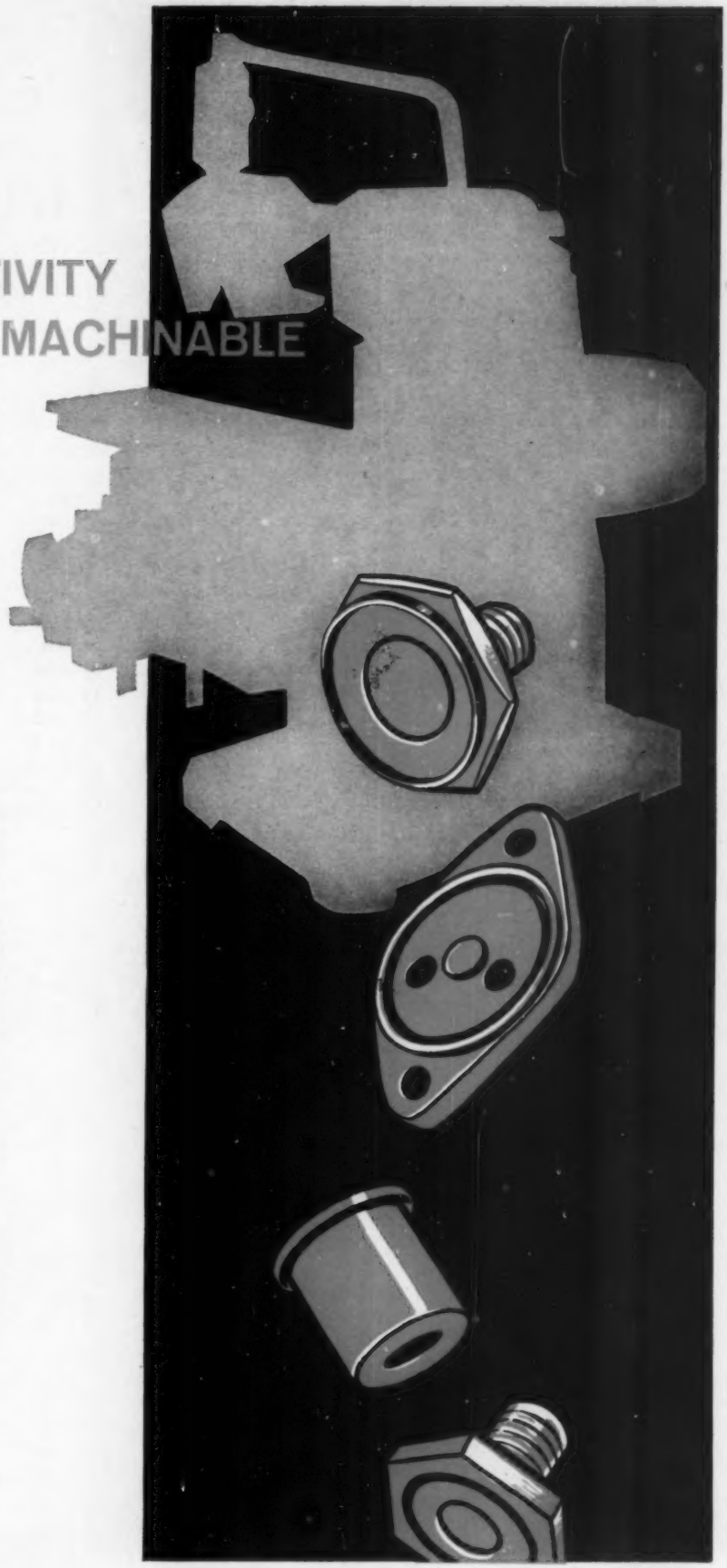

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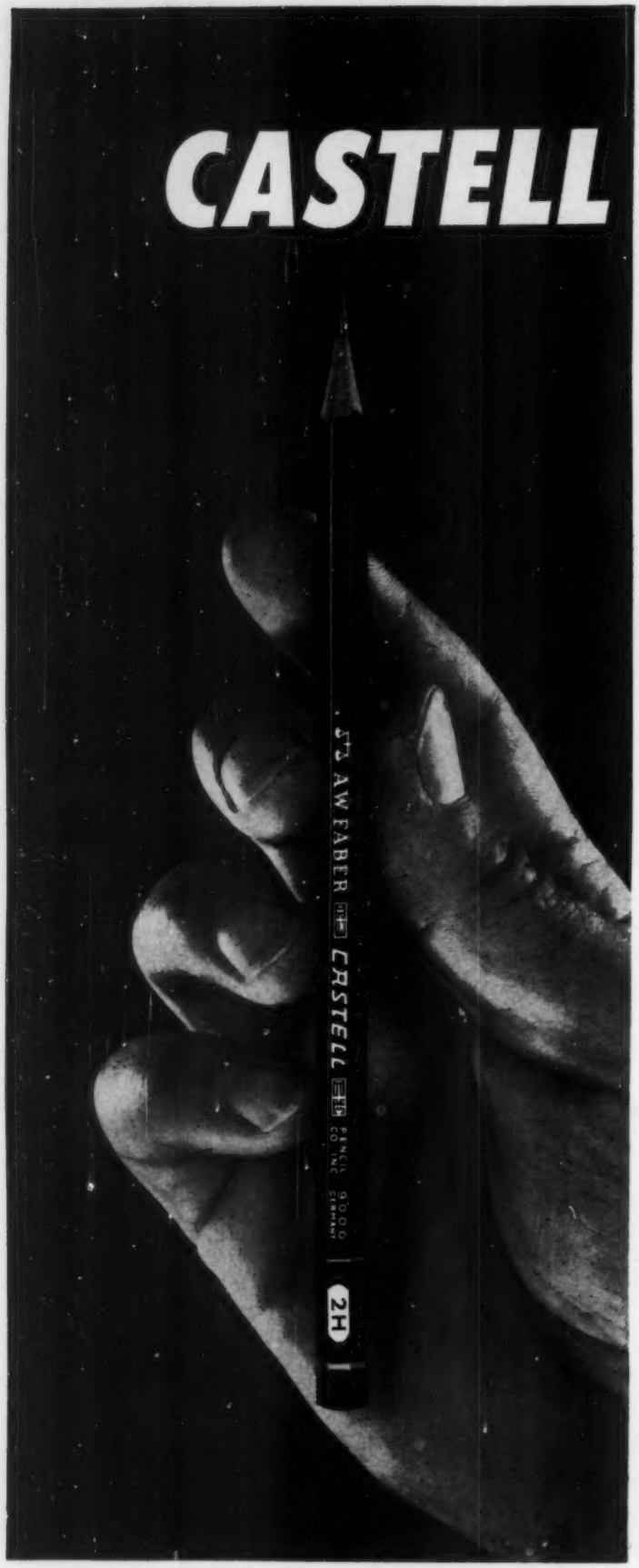

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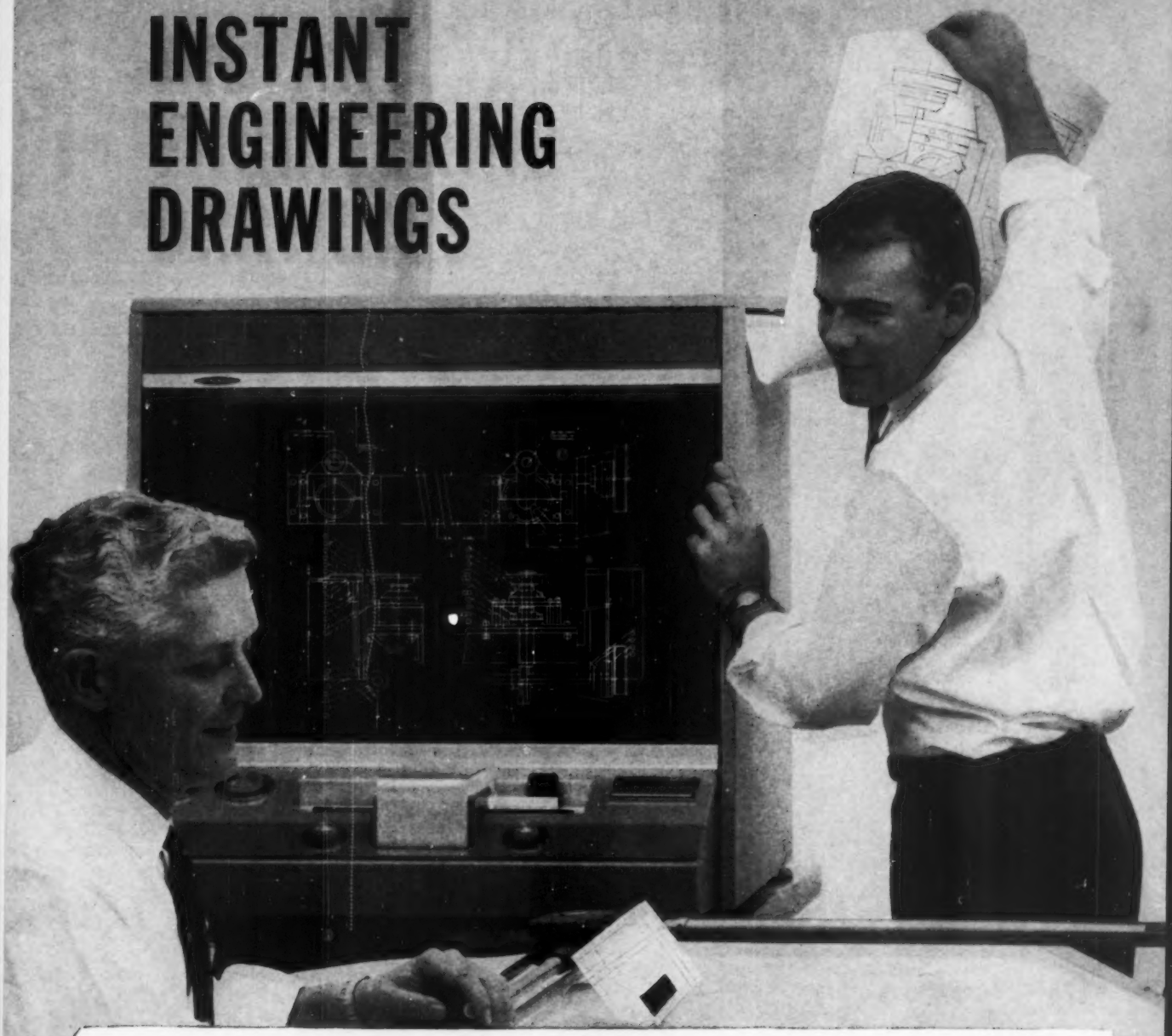

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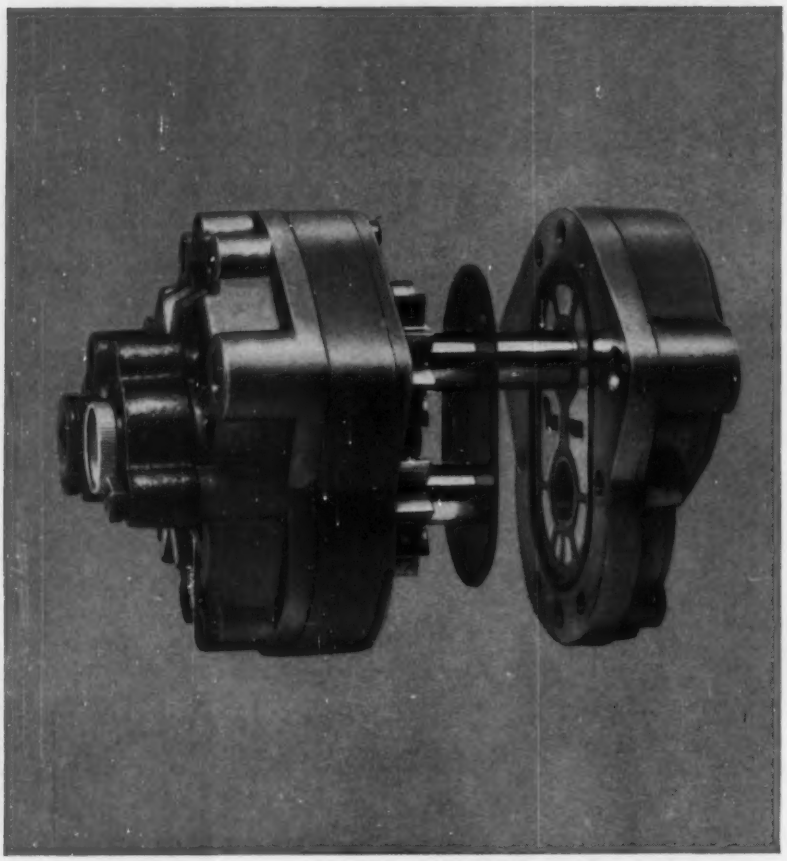
. . . WHERE RESEARCH IS THE KEY TO TOMORROW

F-M WEAR PLATE "RIDES HERD" ON TURBULENT PRESSURE



IN CESSNA'S NEW HYDRAULIC PUMP LINE, F-M WEAR PLATE DIAPHRAGMS KEEP FLUIDS IN LINE to deliver pressures up to 2000 psi for aircraft, farm and construction equipment, many other hydraulic applications. These wear plate diaphragms maintain positive contact with gears to assure high, uniform pressure. To provide a bearing surface for this job, Federal-Mogul applies a high-density bronze to steel by a special sintering process. F-M high-density bronze prevents fluid absorption, and it affords good lubricity, needed because some hydraulic fluids are poor lubricants. To further prevent the escape of hydraulic fluid, these F-M diaphragms are manufactured for a snug, close-tolerance fit in the pump housing.

THE COMPLETE LINE of products from Federal-Mogul Division includes sleeve bearings, bushings, spacers, thrust washers, as well as wear plates. Through the years, F-M has amassed a wealth of knowledge and experience . . . from constant research, from solving bearing design problems for all kinds of products. Our engineers are ready to put this know-how to work and tailor bearing products to your requirements . . . with top performance assured.

FEDERAL Mogul

A DESIGN GUIDE provides valuable engineering data for designers on F-M thrust washers as well as wear plates. Also available is literature on sleeve bearings, bushings and spacers. For your copies, write Federal-Mogul Division, Federal-Mogul-Bower Bearings, Inc., 11043 Shoemaker, Detroit 13, Michigan.

FEDERAL-MOGUL

sleeve bearings · bushings · spacers · thrust washers

DIVISION OF FEDERAL-MOGUL-BOWER BEARINGS, INC.

INTERESTING TO NOTE

SOME eight years ago, Sperry Gyroscope Co anticipated the need for gears which would be so accurate they could be grouped in a train without backlash. These would be essential for ultraprecision devices such as missile-guidance systems and aircraft-navigation computers. The assumption was that gears should be of a fairly stable material like stainless, with all surfaces (not just the pitch line) of each tooth accurate to 10 seconds of arc, and concentric to within 10 millionths of an inch on a 4-in. diameter. Further, Sperry engineers felt that this accuracy could be obtained only by cutting—not by grinding, lapping or shaving a previously cut gear.

Barber-Colman undertook the job of making a hobber. They designed a new type of drive between work spindle and hob spindle which had spur rather than bevel gears. Months of fitting and testing were required to get the relationship between the table and the hob spindle within tolerances, and a whole new system was required to measure it. Sperry engineers clamped a theodolite dial of known error to the table and illuminated it with a strobe light from above. The light was triggered by a precision rotary switch on the hob spindle and a high-speed camera positioned so that it took a picture of the theodolite dial at each contact. When the film was developed, the engineers had a complete graph of the relationship between the two shafts.

Once the mechanism was within tolerances, the gearbox was set in a machine frame. Cutters had to be ground to twice the accuracy previously obtained, a grinder developed to maintain the cutters, then the whole setup shipped from Rockford, Ill, to Great Neck, NY. For shipping, Sperry engineers weren't taking any chances. They loaded the machine tool on a buggy with under-inflated tires and pushed the buggy onto a company truck where it was anchored. Then they built a shed over the machine and drove the truck to Great Neck by selected routes at speeds under 30 mph. Road roughness and tunnel and bridge clearances were both problems, and there were rumors that an engineer sat in the truck cab with a seismograph.

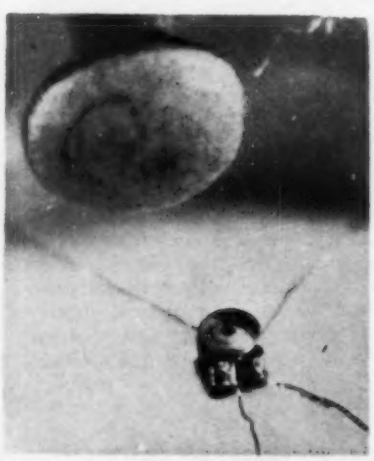
Installation was just as tricky because the machine tool had to be isolated from plant and area vibration. Even its coolant pump had to be mounted off the isolation slab and flexibly connected to avoid *that* source of vibration. Fortunately, the gears justified all the effort. They were even better than specs—so good in fact that a new inspection system was required to test them.

All this is recalled by the article on **special pinions,** p 110. None are as accurate as those Sperry gears, but fortunately they don't have to be.

How small is small

Despite alarums and excursions raised by those who would protect the purity of the English language, "miniaturization" has been accepted as a legitimate word and is, in fact, defined in the new edition of Webster's New International Dictionary (where, incidentally, it is cited in context by quoting from an article by Associate Editor Annesta R. Gardner). But even without the sanction of the dictionary people, engineers have gone on to define three indefinite levels of it: "miniaturization" (making things smaller than before), "subminiaturization" (the next step down) and "microminiaturization" (making things on the tweezer and microscope level). The **wirewrap connections** described on p 86, though small, are useful chiefly on the miniature level.

Today we're thinking in terms of devices even smaller than that. Less than two years ago. Dr. Richard P. Feynman of Cal Tech, in a speech to the American Physical Society, remarked that engraving the Lord's Prayer on the head of a pin is simple stuff compared to the kind of miniaturization possible today. He suggested that it would be possible using only the techniques we know today, to put all 24 volumes of the Encyclopedia Britannica on the head of a pin. His reasoning runs this way: "The head of a pin is ☆ in. across. If you magnify it by 25,000 diameters, the area of the head of the pin is then equal to the area of all the pages of the Encyclopedia Britannica. Therefore, all that is necessary is to reduce all the material in the Encyclopedia by 25,000 times. Is that possible? The diameter of one of the little dots on the halftone reproductions in the Encyclopedia is about 1/120 in. This, when you demagnify it by 25,000 times, is still 80 angstroms in diameter or about 32 atoms across in ordinary metals. One of these dots would contain in its area 10,000 atoms. Hence, there is enough room on the head of the pin to put the Encyclopedia Britannica."



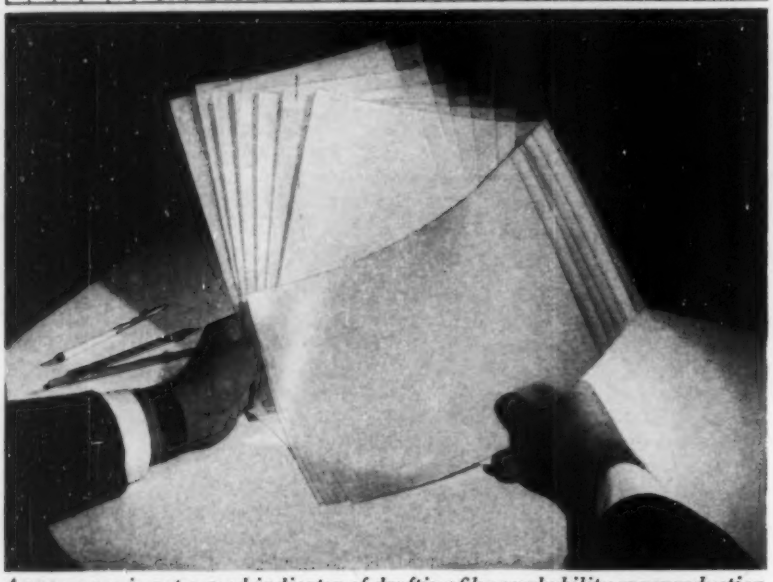
Micromotor (shown with pinhead) delivers 0.000,001 hp at 50 milliamp. Coils are 0.0005-in. copper wire wound on four 0.004-in. poles. Rotor is a permanent magnet and has been run to 1800 rpm.

Feynman went on to describe how it might be done. "We can reverse the lenses of the electron microscope to demagnify instead of magnify. A source of ions, sent through the microscope lenses in reverse, could be focused to a very small spot. We could write with that spot as we write on a TV tube, by going across in lines and having an adjustment which determines the amount of material to be deposited at each spot."

Having dispensed with that problem as if it were an exercise in freshman physics, Feynman searched for new worlds to conquer—and found one "How much space would it take to print all of the books in the world on the scale we have been discussing? It would take, of course, the area of about a million pinheads (or about 3 sq yds) because instead of just 24 volumes, there are 24 million volumes. All of the information which all of mankind has ever recorded in books could be carried in a pamphlet."

In concluding his talk, Feynman threw out a challenge. He offered a prize of $1000 to "the first guy who makes an operating electric motor—a rotating electric motor which can be controlled from outside and with a volume of 1/64 in. cu, not counting lead-in wires." He didn't have to wait long for a claimant. Less than one year later he awarded his prize to William H. McLellan of Electro-Optical Systems Inc, who built an electric motor the size of a speck of dust.

DRAFTING TRENDS



Appearance is not a good indicator of drafting film workability or reproduction quality—see test offer below.

In drafting films, it's the coating that counts

Film Similarities

All drafting films share one common characteristic—*every* major brand employs a polyester base. This polyester material may vary somewhat in grade (from clear to milky) or in gauge (from .002 to .007). However, its properties remain so nearly identical that no appreciable difference in print-back speed can be noted by exposing diazo material through the uncoated film. Accordingly, all polyester films have these unique features: dimensional stability, transparency, flexibility, moisture-resistance and tear strength.

Coating Differences

These advantages mean nothing to the engineer, draftsman or architect until a surface receptive to pencil and ink is put on the film. POST applies three distinct micro-coatings to its polyester film, baking these elements and the film at such high temperatures that they are literally fused. This process also "preshrinks" the material, endowing Polytex with slightly greater dimensional stability.

More Drafting Latitude

The net result of the exclusive POST *coating process is the most durable drafting film surface available*—a surface on which, if circumstances demand, you can use the hardest grade of pencil without destroying the coating. Some pencils work better than others, of course. Plastic-based pencils are best of all when permanency or washability are considered.

Test Offer

To convince you, regardless of previous or present drafting film experience, that POST Polytex offers a superior coating with outstanding erasibility, pencil and ink adhesion, a free Polytex test kit is yours without obligation. We'll mail an 8½ x 11 drafting film sample, plus a vinyl eraser and drafting pencil assortment, packed in a POST Pocket Protector. Write for it on your letterhead today. *Frederick Post Company, 3642 N. Avondale Avenue, Chicago 18, Ill.*

POST

SENSITIZED PAPERS & CLOTHS • TRACING & DRAWING MEDIUMS • DRAWING INSTRUMENTS & SLIDE RULES
ENGINEERING EQUIPMENT & DRAFTING SUPPLIES • FIELD EQUIPMENT & DRAFTING FURNITURE

READER TO EDITOR

Welder's automatic mask

To the Editor:

In reference to your article on p 32 of the May 15, 1961, issue, asking the question, "Why don't they invent a welder's mask with an automatically controlled window that gives a clear view of the work before the arc is struck." There is one!

The Auto-View Welding Helmet, manufactured by Auto-View Welding Co, Santa Monica, Calif, is a helmet that works on the principle of silent commands . . . that is, when the welder wants to see, he simply opens his mouth. A chin-actuated lever removes the light filter from his view.

—HENRY C JORDAN
Los Angeles, Calif

Linear motors

To the Editor:

I recently read the article by G. A. Francis discussing linear power actuators (*PE—Sep* 18 '61, *p* 86). In 1958 our company developed Linear Positioning Motors. We are now in production of many models of this motor which differs from Skinner's Polynoid Linear Actuator in that we use a dc source to establish a magnetic field which drives an armature to an equilibrium position within the field.

The number of available shaft positions is limited only by the customer's specifications and by physical considerations. The instantaneous position of the magnetic field is controlled by switching. Force available is a function of cross-sectional size of the motor. To date we have developed motors with forces varying from ounces to 100 lb (intermittent) and 50 lb (continuous). Models are available that require approximately 70 millisec to travel 1½ inches.

—ARTHUR B OLSON
Tronics Corporation
Minneapolis

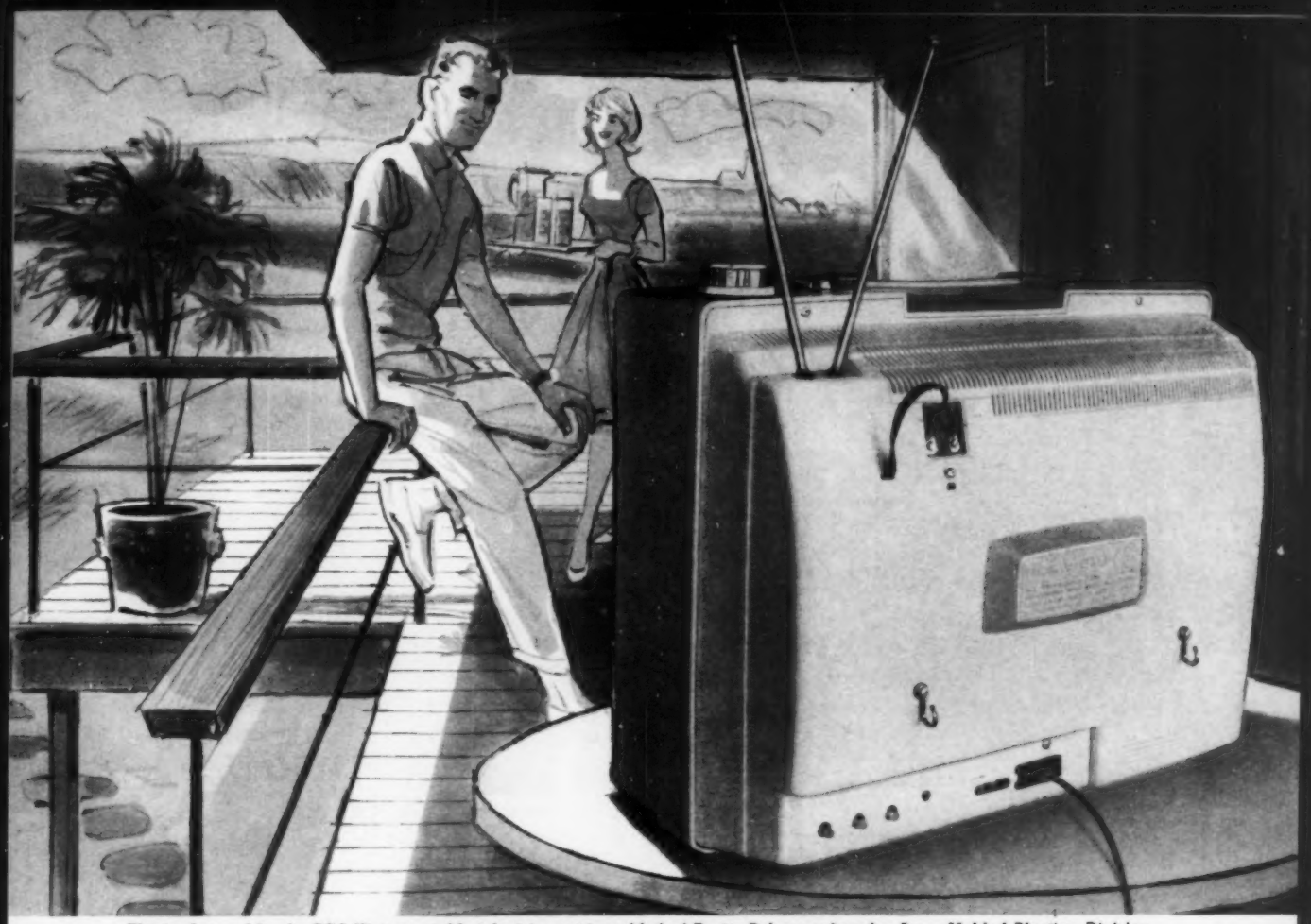
Noah was "tuned in"

To the Editor:

In reference to your editorial on Noah (*PE—Aug* 21 '61, *p* 31) and R D Martin's letter (*PE—Oct* 2 '61, *p* 12) quite a few of us could approach Noah's ability if we became attuned with the "Engineer of the Universe." A few years ago, I wouldn't have believed the preceding statement either, but then I discovered what an engineering and management handbook the Great Book can be.

Not only will "tuning" improve one's personal relations with his co-

continued, page 14



The back panel for the RCA Victor portable television set is molded of Tenite Polypropylene by Amos Molded Plastics, Division of Amos-Thompson Corp., Edinburg, Indiana.

A great show by a plastic—
TENITE POLYPROPYLENE

Long-run performance and a handsome appearance—two design essentials—are featured in the back panel of the RCA Victor portable TV set. The material that made them possible is Tenite Polypropylene.

Tough, durable Tenite Polypropylene takes the knocks and jolts, protecting the delicate internal components of the set. It withstands elevated temperatures—articles made from it can even be sterilized. Yet the flow properties of Tenite Polypropylene result in such injection-molded details as a leather-grained texture, clean ventilating slots, and sharp, three-dimensional lettering. And having the lightest weight of any solid plastic is its special contribution to portability.

This last property can often mean more finished pieces per pound—one of many economies found in Tenite Polypropylene. For example, its "built-in hinge" property (one sample flexed a million times without cracking) permits two-part articles to be molded as one piece, without need for conventional hinging. Another important saving results from the unusual strength of Tenite Polypropylene—products can have thinner walls.

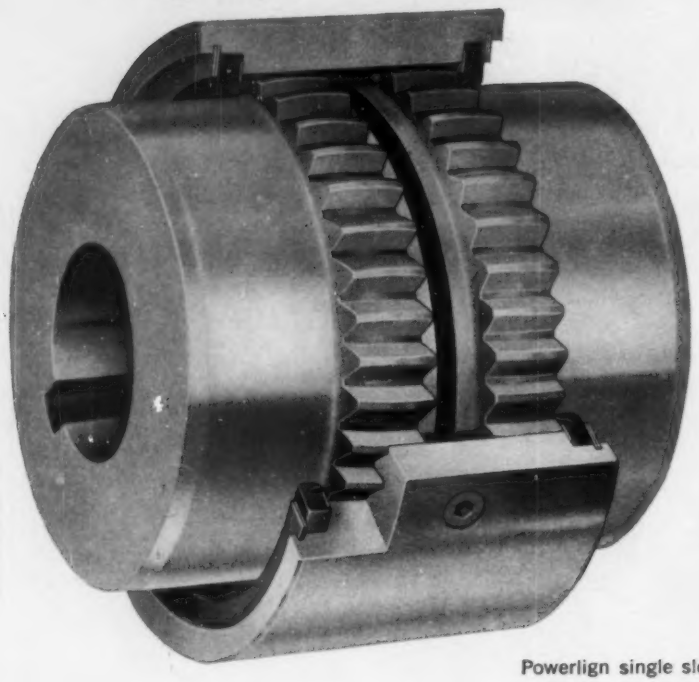
Tenite Polypropylene may also be extruded into a wide variety of things—clear, printable, heat-sealable film...weather-resistant monofilament...sheet for thermoforming...insulation for wire...pipe for chemicals. And wherever color is important, Eastman offers more than 42,000 colors and color effects, in custom-compounded Tenite Polypropylene or in color concentrates for mixing with the uncolored plastic.

The advantages of Tenite Polypropylene may include several benefits for your product, and Eastman technical representatives and laboratory facilities are ready to help you find out. For details on this exciting new Tenite plastic, write EASTMAN CHEMICAL PRODUCTS, INC., subsidiary of Eastman Kodak Company, KINGSPORT, TENNESSEE.

TENITE®
POLYPROPYLENE
an Eastman plastic

CIRCLE 13 ON READER SERVICE CARD

High performance



Powerlign single sleeve

Low cost, with new tooth form

Here's a new approach to coupling design—Waldron's Powerlign single Sleeve Coupling with unique profile gear teeth. The new sleeve tooth shape is broached, flat from root to tip and from end to end. It has a wider base, more pitchline contact under misaligned conditions than do involute forms. The new crown type of involute hub tooth, together with the rugged flat profile teeth in the sleeve provides greater strength and more than the usual misalignment capacity. Write for literature on the Powerlign coupling.

Size & Max. bore	Rough bore	HP/100 rpm	Max. rpm
1⅛	31/64	4	23,000
1⅜	23/32	12	19,000
2⅛	23/32	26	15,500
2⅜	23/32	48	12,800

WALDRON-HARTIG, Box 791, New Brunswick, N.J.
a division of Midland-Ross Corporation MR

WALDRON
Makes it easy to pick the right Couplings

workers; but also a lot of negative attitudes toward the management and the world in general will, in time, disappear. Also, in short order, one begins to enjoy his work to a greater degree than he ever thought possible, and as a bonus, one's creative efforts will begin to yield more worthwhlie ideas than in the past, with probably somewhat less eyebrow wrinkling.

Noah was "tuned in" to a high degree, so he didn't have to search down numerous blind alleys for answers to his problems. He may have fumbled a few times, but not as much as we do today. Today's engineering files are loaded with "blind-alley" reports. I know; I've been the author of quite a few.

Even if we only "tune in "occasionally, we still can get a little help now and then from the Almighty Supervisor. It helps make a rough road, not quite so rough, and quite often a real short-cut is opened up to us. That's the real key to all of this creativity business. —R A ENGSTROM
Moline, Ill.

COMING EVENTS

NOVEMBER

13-16 . . . . Institute of Radio Engineers, Conference on Magnetism and Magnetic Materials, Hotel Westward Ho, Phoenix

26-Dec 1 . . . . American Society of Mechanical Engineers, Winter Annual Meeting, Statler Hilton, New York City

DECEMBER

4-5 . . . . New York Univ, Conference on Beryllium Metallurgy, College of Engineering, University Heights, New York City

12-14 . . . . Institute of Radio Engineers, AIEE, ACM, Eastern Joint Computer Conference, Sheraton Park Hotel, Washington

JANUARY

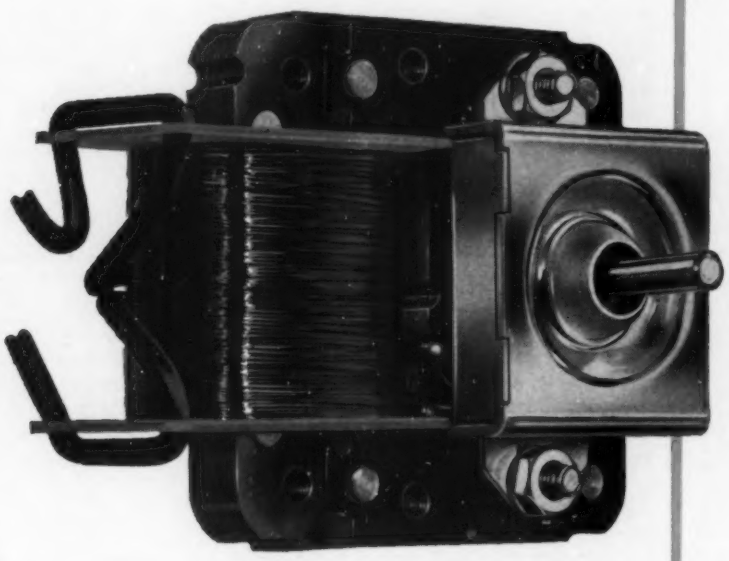
8-12 . . . . Society of Automotive Engineers, Automotive Congress & Exposition, Cobo Hall, Detroit

9-11 . . . . Institute of Radio Engineers, 8th National Symposium on Reliability & Quality Control, Statler-Hilton Hotel, Washington

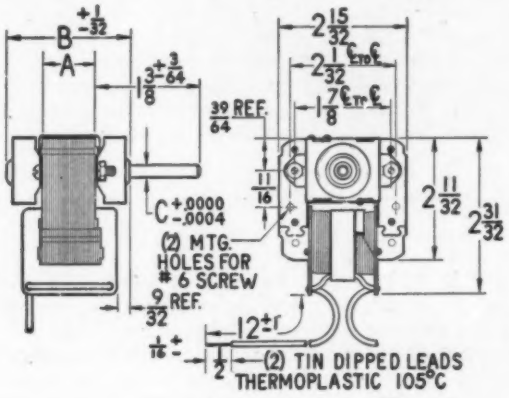
28-Feb 2 . . . . American Institute of Electrical Engineers, Winter General Meeting, Statler-Hilton Hotel, New York City

NEW TYPE EA1 UNIVERSAL SKELETON MOTOR

a superior unit because of quality construction, larger bearings and greater oil capacity



- Larger bearings and greater oil-felt capacity give longer motor life.
- Grooved bearings insure continuous oil return.
- Larger bearings reduce motor noise.
- Accurate metallurgical control of laminations insure uniform performance.
- Interchangeable mountings.
- Six standardized models, 1/500 to 1/45 HP.
- The correct motor for rotisseries, vending machines, office machines, chart drives, phonographs, slide projectors, heaters, refrigerators, hair dryers, deodorizers, 2" to 8" diameter fan blades, electronic equipment, etc. Write for complete specifications on your requirements.



SPECIFICATIONS

UNIVERSAL TYPE EA1 SKELETON MOTORS 115 VOLT 60 CYCLE

MODEL	HP @ 2,800 RPM	MAXIMUM TORQUE oz. in.	DIMENSIONS		
			A	B	C
EA1A	1/500	1.1	3/8"	1 53/64"	.1817
EA1B	1/350	1.4	1/2"	1 41/64"	.1817
EA1D	1/130	3.3	3/4"	2 3/16"	.1817
EA1E	1/90	4.5	1"	2 7/16"	.1817
EA1G	1/60	6.5	1 1/2"	2 15/16"	.250
EA1J	1/45	7.5	2"	3 7/16"	.250

12" leads on all models

57

UNIVERSAL ELECTRIC COMPANY

PRECISION ELECTRIC MOTORS

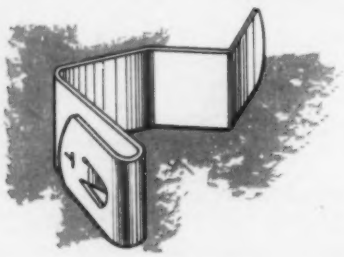
EXECUTIVE AND GENERAL SALES OFFICES: OWOSSO, MICHIGAN, DEPT. 12

INFORMATIVE NOTES TO IMPROVE YOUR PRODUCT... SAVE YOU MONEY

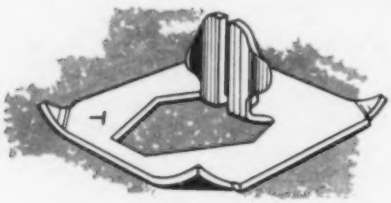
Published as a service to Designers and Engineers

Ideas from Tinnerman have cut costs, improved products. Here are examples from Tinnerman's 10,000 variations of SPEED NUT brand fasteners —all stamped with the T-mark of *total* reliability.

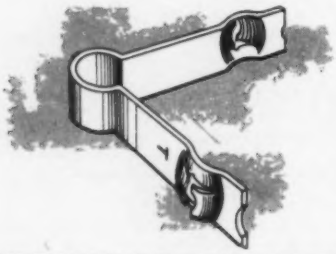
Tinnerman can help *you* cut costs with a free Fastening Analysis of your product. Call your Tinnerman representative, or write: *Tinnerman Products, Inc., Department 12, P. O. Box 6688, Cleveland 1, Ohio.*



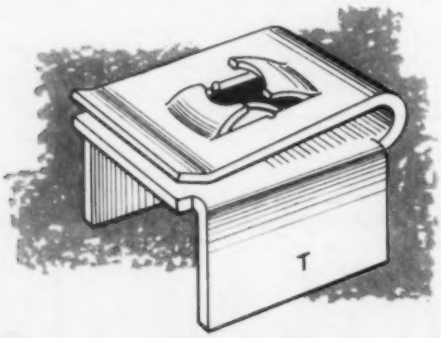
MASONITE PANEL CLIP retains back panel of a TV cabinet, may be applied to many types of covers, panels, access doors, and displays. "U" section locks by hand on panel edge, spring leg snaps over flange of metal cabinet. This SPEED CLIP® fastener *eliminated eight drilling and screw operations, cut assembly time in half*, substantially reduced materials handling for TV manufacturer.



WIND CORD CLIP has wide usage wherever fabric must be fastened to metal panels. Dart-type, self-anchoring tabs snap into wire weave and mounting holes, draw gripping corners down tight. *Assembly requires only thumb pressure.* Allows smoother fastening with fewer parts. First used for fastening insulation cord in car doors.



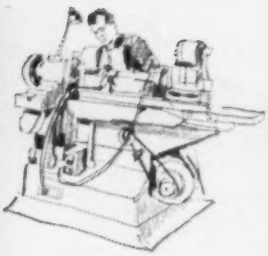
ANGLE BRACKET fastens mitered corners of extruded aluminum channel sections, *replaces awkward tapped angle bracket.* One of a large line of SPEED NUT angle fasteners. Relieved corners allow for heavy burrs on sawed edges, provide flexibility to offset hole misalignment. Originally designed for storm sash, these fasteners can also be used in picture framing, metal doors and windows, cabinets and display cases.

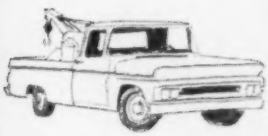


SPACER SPEED NUT fastener eliminates lockwashers, riveting, welding, staking, clinching, provides clearance for counter-punched holes. Fastener is vibration-proof, self-retaining and easily removable. Built-in spacing legs eliminate separate spacers, *cutting parts handling and inventory, lowering assembly time and costs.* Spacer SPEED NUT fasteners are available in a wide range of sizes.

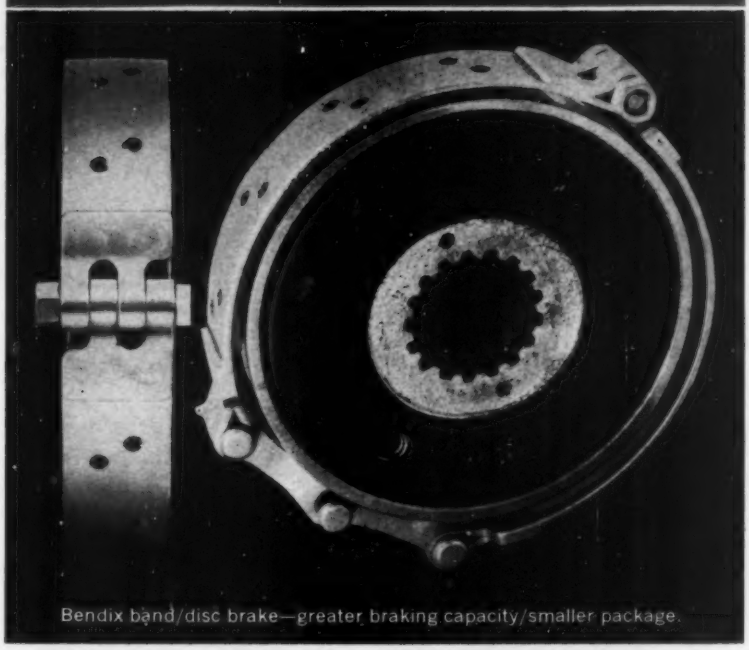
CANADA: Dominion Fasteners Ltd., Hamilton, Ontario. GREAT BRITAIN: Simmonds Aerocessories Ltd., Treforest, Wales. FRANCE: Simmonds S.A., 3 rue Salomon de Rothschild, Suresnes (Seine). GERMANY: Mecano Simmonds GMBH, Heidelberg.

TINNERMAN
Speed Nuts®
Look for the Tinnerman "T"

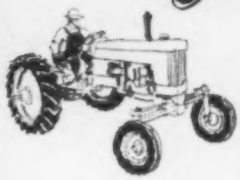


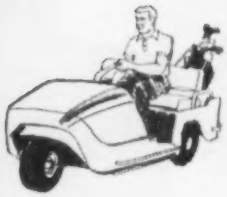


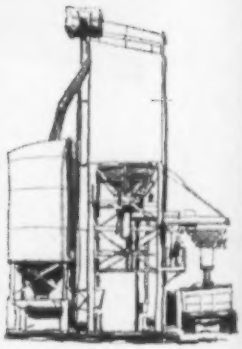
Bendix mechanical brake—built to "take it" under severest wear.

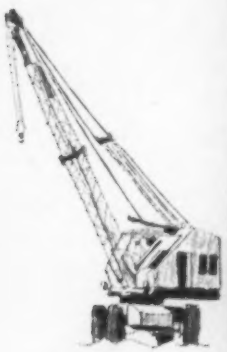


Bendix band/disc brake—greater braking capacity/smaller package.









BENDIX SMALL, MULTI-PURPOSE BRAKES GIVE BETTER CONTROL IN UNLIMITED APPLICATIONS

Practically any application you can think of—golf cart, power saw, tractor, oil rig, steam shovel—can use the benefits of Bendix small, multi-purpose brakes. **The Bendix® band/disc brake** gives greater torque capacity while reducing brake size. It provides maximum lining area in minimum space; permits rapid heat dissipation. **The small mechanical brake** is economical, easy to install and adjust, requires little maintenance. Light and compact, it packs man-sized power in 4 lbs. of brake and drum. Available in complete range of sizes. These small, multi-purpose brakes could be the answers you've looked for. Write us at South Bend, Indiana, for sizes and actuations available.

Bendix Products Automotive Division

THE Bendix CORPORATION

CIRCLE 17 ON READER SERVICE CARD

STRENGTH + LIGHT WEIGHT
That's the Beauty of Steel

DESIGN NOTE: The Military Ranger used N-A-XTRA 90 (minimum yield strength, 90,000 psi) in bars and plates ranging to 1" thick, in main frame and cross members, loader mechanism and fork carriage. Fabrication followed standard gas cutting and welding procedures. Excellent weldability of N-A-XTRA was important in joining to other steels.

N-A-XTRA 90 plates and bars are used in the "Ranger," a rough terrain military vehicle designed, developed and fabricated jointly by the U. S. Army Quartermaster Corps and the Clark Equipment Company, Battle Creek, Michigan. The Ranger series is manufactured by the Industrial Truck Division of Clark Equipment Company.

Great Lakes Steel is a Division of

ROUGH TERRAIN MILITARY FORK TRUCK USES

N-A-XTRA

HIGH-STRENGTH STEEL FOR MAXIMUM LOADABILITY WITH MINIMUM WEIGHT

The U. S. Army needed a material handling truck in 6, 10 and 15 thousand-pound-capacity sizes that would, among other things, operate in five feet of salt water . . . traverse sand beaches, rough terrain . . . climb 45% grades at a minimum of 2.0 m.p.h. . . . 15.0 m.p.h. loaded on the highway . . . load and unload from the far side of a flat car . . . tilt loads 30 degrees back, 45 degrees forward, 10 degrees from the horizontal left or right. *And all this within dimensional and weight requirements that would allow air transport of the vehicle.*

The U. S. Army Quartermaster Corps and the Industrial Truck Division of Clark Equipment Company came up with the answer—the Military Ranger. It meets or exceeds every operating requirement. And does it within the vital weight limit by using N-A-XTRA 90 high-strength steel in main frame, cross members, loader mechanism and supporting structure. N-A-XTRA handles the job in these high-stress areas, yet weighs three times less than mild carbon steel of equivalent strength.

You may never have to air-lift your equipment, but that's not the only problem N-A-XTRA solves. Rugged operating conditions, heavy loads and weight-saving construction—in such applications as, for example, heavy machinery and pressure vessels—are challenges that N-A-XTRA is designed to meet and beat.

With excellent weldability, formability, and toughness even at subnormal temperatures, N-A-XTRA low carbon, extra-strength alloy steels give superior results with conventional fabricating methods, including cold forming, gas cutting, shearing and machining. N-A-XTRA high-strength steels are available in four levels of minimum yield strength, from 80,000 to 110,000 psi, and in sizes ranging from ⅛ to 1¼″ thick, up to 72″ wide and up to 35′ long. For further information, write Great Lakes Steel Corporation, Product Development, Dept. PE-16, P. O. Box 7310, Detroit 2, Michigan.

a product of

GREAT LAKES STEEL

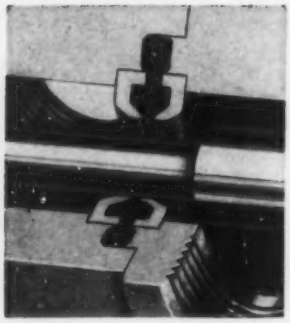
Detroit 29, Michigan

N-A-XTRA STEELS ARE AVAILABLE AT THESE STEEL SERVICE CENTERS

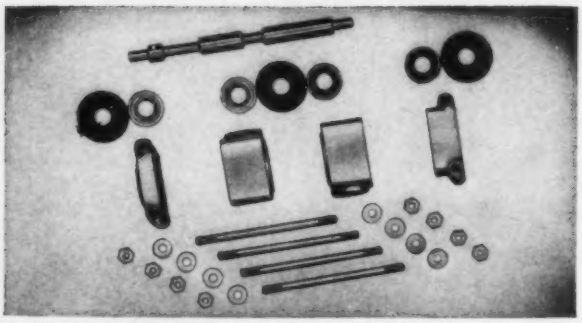
Benedict-Miller, Inc. Lyndhurst, New Jersey	Joseph Demsey Co. Cleveland, Ohio	Ducommon Metals & Supply Co. Los Angeles, California
Interstate Steel Co. Des Plaines, Illinois	Lockhart Iron & Steel Co. Pittsburgh, Pennsylvania	Marsh Steel & Aluminum Co. Kansas City, Missouri
O'Neal Steel, Inc. Birmingham, Alabama	Salt Lake Hardware Co. Salt Lake City, Utah	A. C. Leslie & Company, Ltd. Montreal, Canada

NATIONAL STEEL CORPORATION

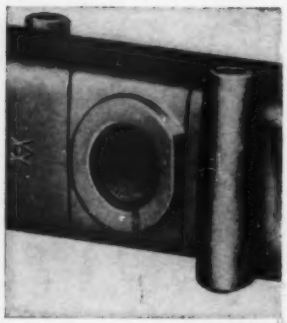
Do the air valves you buy include these quality features?



SEAL—Exclusive, triple-supported seals permit interference fit of spool for extra-tight closure with minimum wear. Usual damage to conventional "O" rings by moving spool is eliminated.

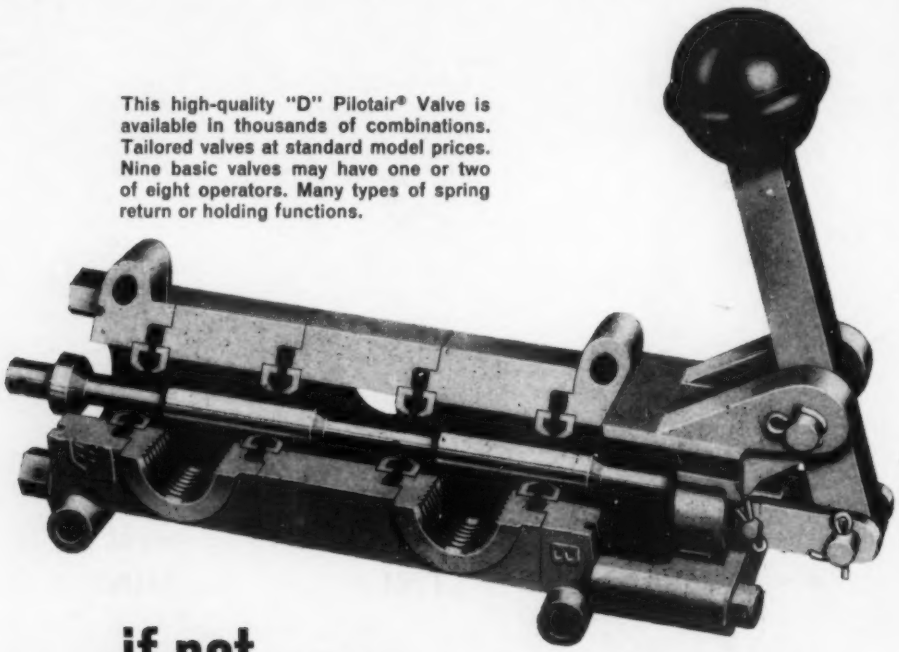


SIMPLICITY—Uncomplicated parts mean long life and easy servicing. Common parts are used extensively to simplify stocking or repair.



FLEXIBILITY—Modular Construction. Operators, mounting holes and ports may be independently rotated in 90° steps. Operator may be on either or both ends.

This high-quality "D" Pilotair® Valve is available in thousands of combinations. Tailored valves at standard model prices. Nine basic valves may have one or two of eight operators. Many types of spring return or holding functions.



if not, the chances are your maintenance costs are higher than necessary. For more information about quality Fluid Circuitry Controls for trouble-free automation, ask for Catalog A4-75.01.

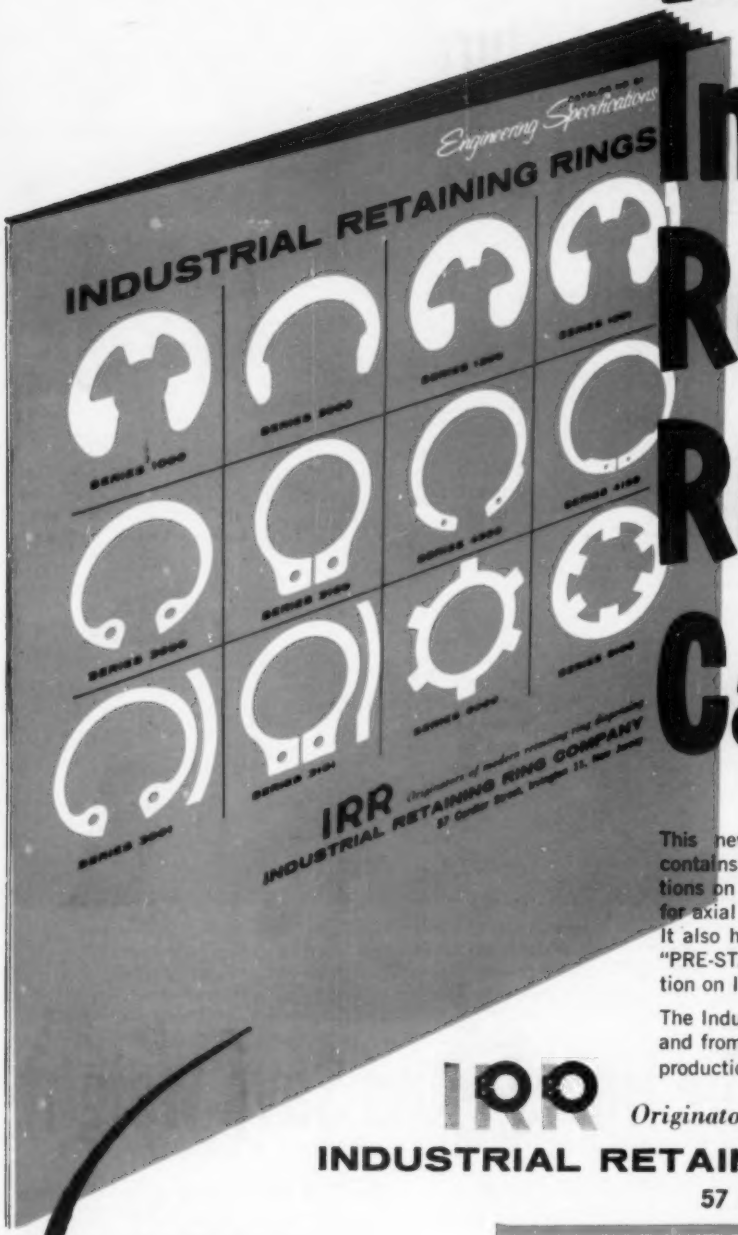
See the Yellow Pages under Cylinders for the Name of Your Local Distributor, or refer to Sweet's Catalog, Product Design File.

WESTINGHOUSE AIR BRAKE COMPANY

INDUSTRIAL PRODUCTS DIVISION, WILMERDING, PENNSYLVANIA

For YOUR File . . .

New! Industrial Retaining Ring Catalog



This new Industrial Retaining Ring Catalog, No. 61, contains complete information and engineering specifications on IRR Internal and External Retaining Rings—both for axial and radial assembly—from sizes .040" to 4.125". It also has information of the exclusive, time-saving, IRR "PRE-STACKED" Axial Assembly Rings as well as information on IRR Pliers and Accessories.

The Industrial Retaining Ring Catalog is easy to work with and from. It will greatly assist in design, purchasing and production.

IRR

Originators of modern retaining ring dispensing

INDUSTRIAL RETAINING RING COMPANY

57 Cordier Street, Irvington 11, New Jersey

Use for FREE Samples and Catalog

INDUSTRIAL RETAINING RING COMPANY
57 Cordier Street, Irvington 11, N. J.

Please, send me samples of Industrial Retaining Rings and the new IRR Catalog No. 61.

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Company .....

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City ..... Zone ..... State .....

Standard Forge & Axle Co. forges 5-inch by ½-inch Pittsburgh Seamless Mechanical Tube ends down to 2⅝" solid steel wheel spindle ends (cross section above). The Montgomery, Ala., plant then machines and grinds bearing surfaces to .0005-inch tolerance to produce single-piece, 20,000 pound capacity trailer axles. Trailer operators benefit from higher payloads because . . .

They Throw Away The Holes—And Save Weight

The trick in making a seamless steel tube is piercing a hole in a round of solid steel.

But Pittsburgh Steel Company's Seamless Steel Mechanical Tubing makes the full circle in production of trailer axles at Standard Forge & Axle Co., Montgomery, Ala.

Standard, in effect, throws away the holes by forging the tube ends down to solid steel again, leaving only a hollow steel center and spindle section.

The result: a lightweight, one-piece trailer axle made entirely from a single length of seamless tube—including load bearing wheel spindles, precision ground for bearing and seal seats.

The advantage: assured strength and safety of seamless steel, plus, for example, reduced axle weight for trailer operators in a 20,000 pound capacity axle.

Starting with a seamless steel tube 5" x ½" x 87⅞" for this particular axle, Standard upsets both ends, then swages them down to the shape of a spindle with a 2⅝" solid end.

That's deformation of the roughest kind.

But Pittsburgh Seamless Mechanical Tubing takes it in stride, then bounces back under heat treatment with the physical properties required for precision finishing of the critical spindle surfaces, and the toughness necessary for a long life in hard service.

And that kind of performance takes seamless steel tubes with exceptional internal soundness, consistent grain structure, and chemical and dimensional uniformity.

Pittsburgh C-1040 grade Seamless Mechanical Tubing supplies these properties consistently—for this type

After upset, Pittsburgh Seamless Mechanical Tubes, with 5-inch OD and ½-inch wall, are swaged to solid steel spindle shape on drop forge, at right. Standard's heat treating process refines grain, restores toughness of steel.

Standard also produces high-strength inserted spindle trailer axle by inserting forged alloy steel spindle with 4.065-inch OD into 4.040-inch burnished ID of 5-inch seamless steel tube under 50,000-pounds pressure.

Standard Forge & Axle Sales Manager James A. Rumbley says Pittsburgh Steel Company, as longtime major supplier of seamless mechanical tubes, "leaves nothing to be desired in product or service."

axle and for Standard's high-strength inserted spindle type.

James A. Rumbley, Standard's sales manager, says:

"Trailer axles are high-weight carrying members subject to tremendous load shocks. So we use the finest materials available to assure our customers trouble-free service. Seamless steel mechanical tubes help us to do that, with complete safety and at less weight.

"For many years, Pittsburgh Steel Company has been one of our major tubing suppliers. It has left nothing to be desired either in product or service."

That's standard practice with Pittsburgh Steel—whether supplying seamless mechanical tubing to Standard's specific requirements, or to yours. Be certain with Pittsburgh Seamless. Contact one of the district offices listed below.

Pittsburgh Steel Company

Grant Building • Pittsburgh 30, Pa.

DISTRICT SALES OFFICES

Atlanta	Cleveland	Dayton	Los Angeles	Pittsburgh
Chicago	Dallas	Detroit	New York	Tulsa
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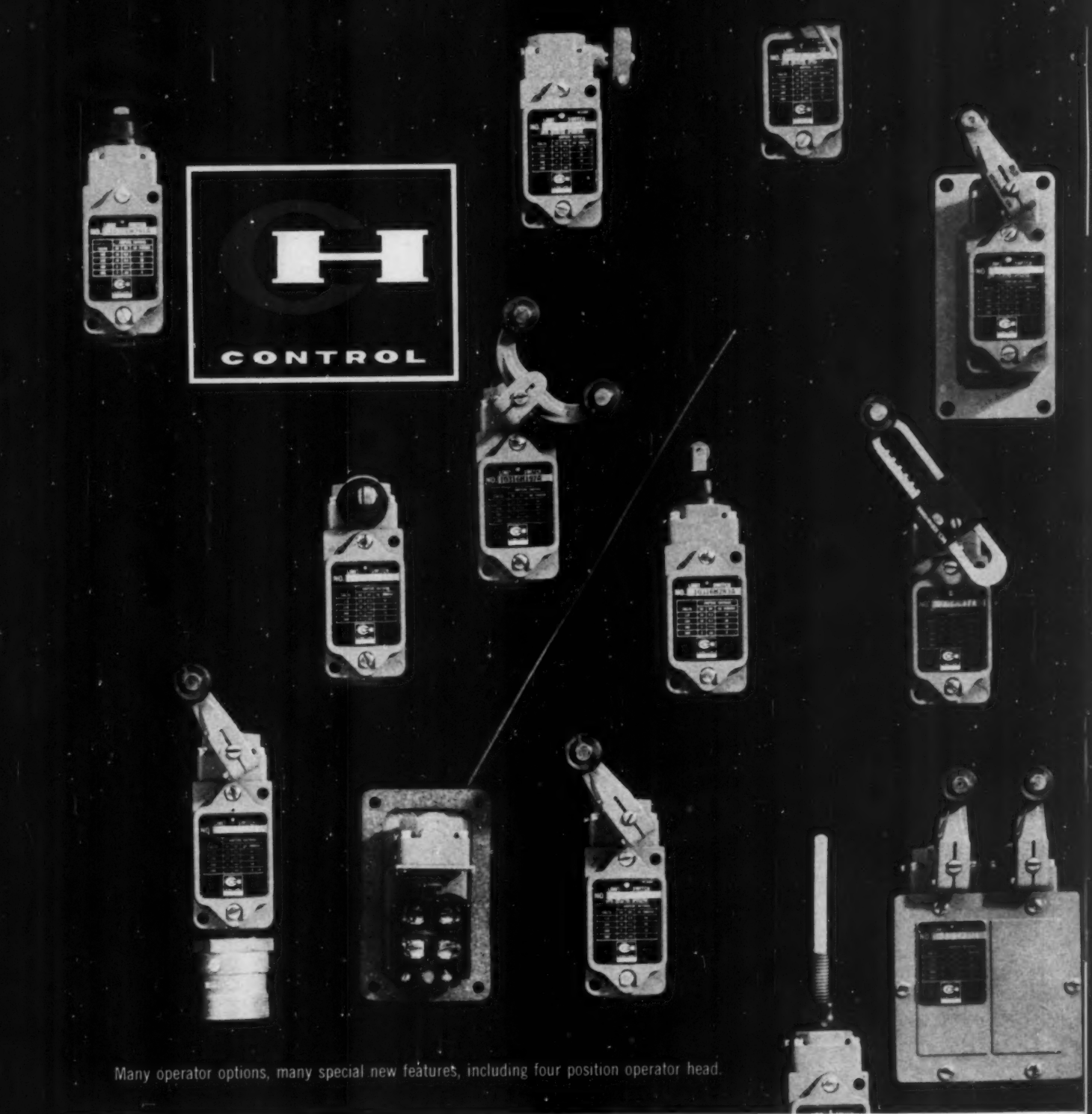
Steel

What's your problem? If you can solve it with a

New Cutler-Hammer operator options provide top flexibility... world's best oiltight limit switch

For any use, anywhere, in any position . . . you just can't buy a more reliable, longer-life switch. No other switch is sealed more effectively . . . effectiveness we've proved under test conditions so rugged they will never be equaled in actual service. Even the silver-to-silver contacts are visible for quick inspection. For full details on this complete new line, write for Pub. **ED-145W249.**

For any electrical control problem, contact your local Cutler-Hammer sales office or distributor. They'll supply you with the finest electrical components, the finest service and technical help.



Many operator options, many special new features, including four position operator head.

limit switch, your best answer's here!

WHAT'S NEW? ASK...

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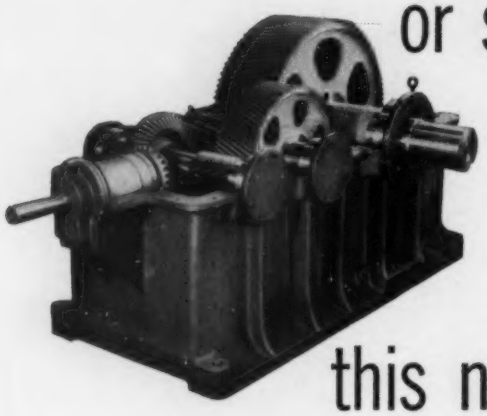
CONTROL

CIRCLE 25 ON READER SERVICE CARD

If you need gear drives that can deliver more power in less space... reduce vibration

or sound levels... or operate at higher speeds yet last longer... look for this nameplate.



It means that drive gearing has been hardened and precision ground to give radically improved gear accuracies. Yet they cost no more. For full details...

write on your company letterhead for "An Advanced Concept in Modern Gearing"

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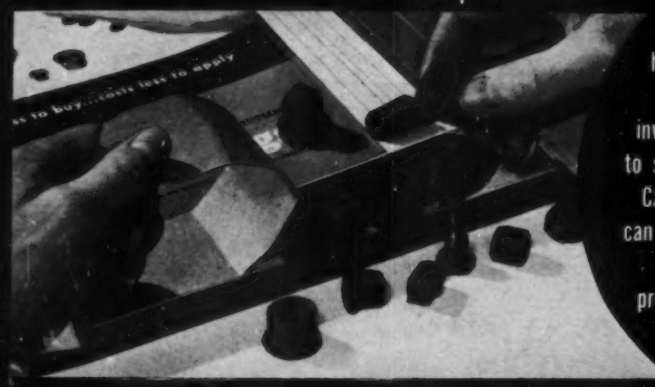
PHILADELPHIA GEAR DRIVES

PHILADELPHIA GEAR CORPORATION
King of Prussia (Suburban Philadelphia), Pa.



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CAPLUGS DIVISION, PROTECTIVE CLOSURES CO., INC.
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MAIL a free assortment of Caplugs, literature and prices to us, without obligation.

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molded of tough, flexible Polyethylene

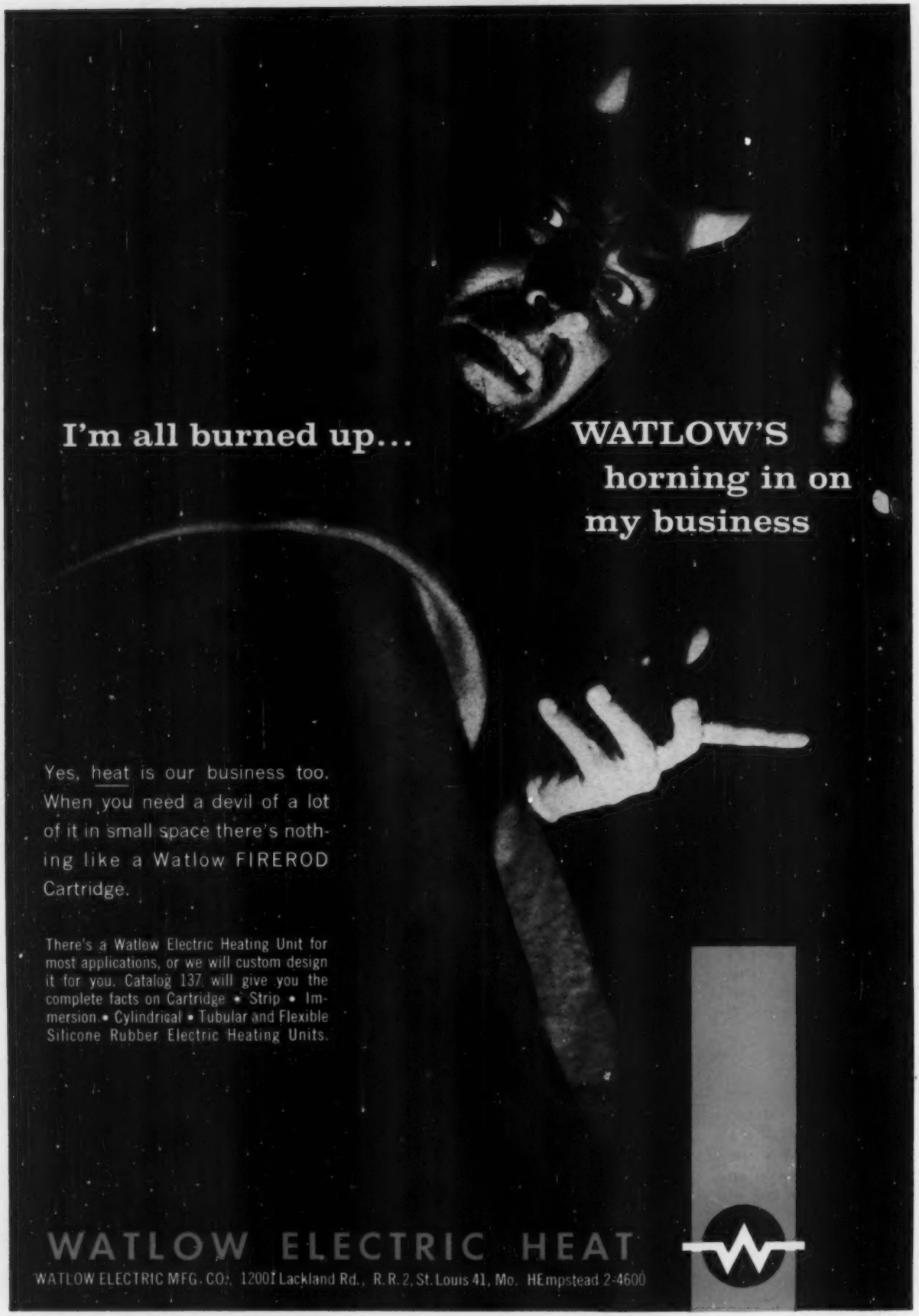
unaffected by most chemicals

easy to apply... and remove

won't chip, break, shred, or collapse

Caplugs

A full family of closures to meet almost any need you can name . . . over 600 sizes in numerous styles and colors now in stock.


I'm all burned up...
WATLOW'S horning in on my business
Yes, heat is our business too. When you need a devil of a lot of it in small space there's nothing like a Watlow FIREROD Cartridge.
There's a Watlow Electric Heating Unit for most applications, or we will custom design it for you. Catalog 137 will give you the complete facts on Cartridge • Strip • Immersion • Cylindrical • Tubular and Flexible Silicone Rubber Electric Heating Units.
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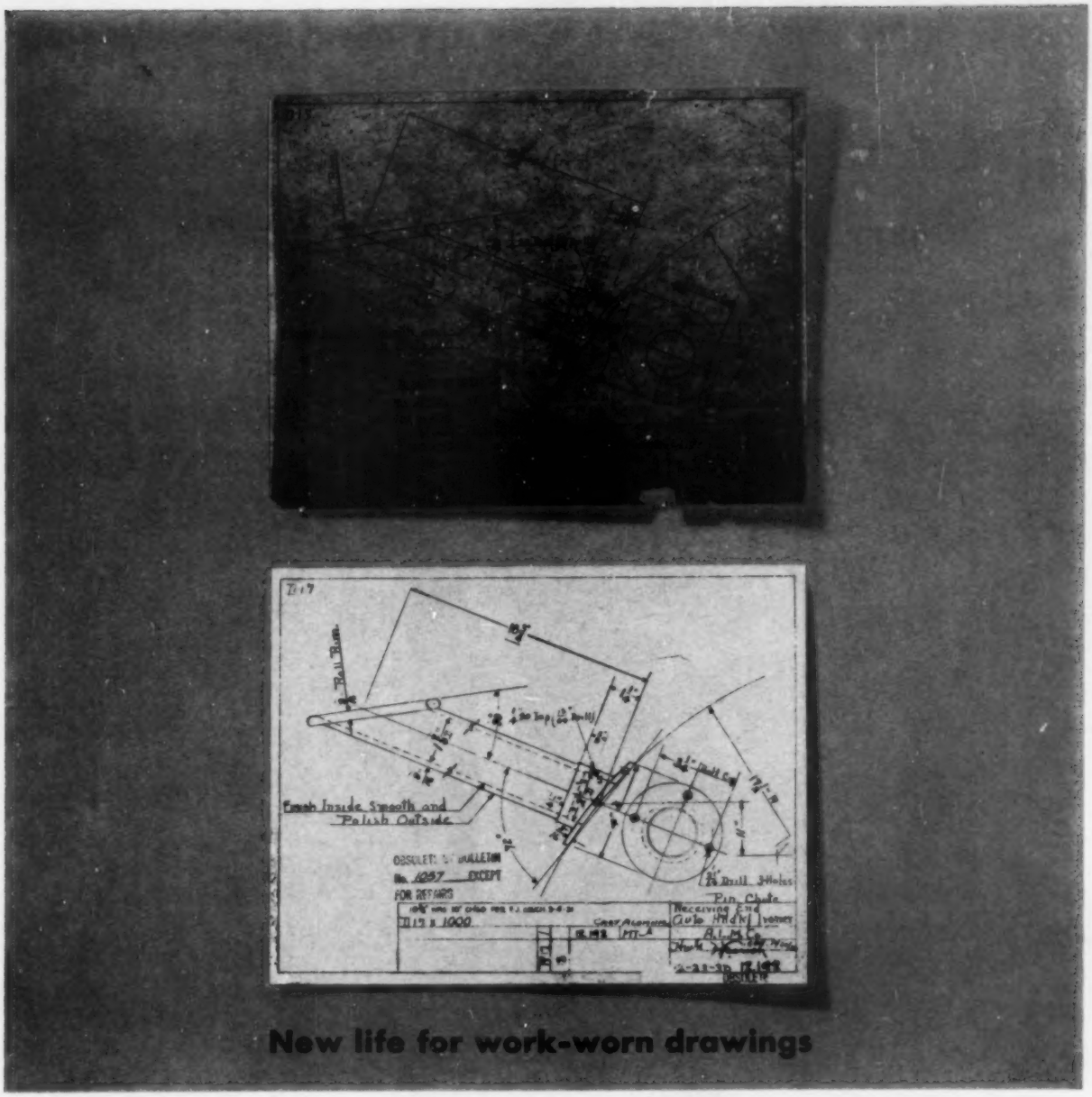
6132



New life for work-worn drawings

. . . at a fraction of the usual redrawing time and cost! Now you can transform tired-out, tattered originals into crisp, legible drawings again. You can do it quickly and easily, too, without costly, tedious redrafting—simply by making "second originals" on Du Pont CRONAFLEX® Direct Positive Film!

Drawings wrinkled and dog-eared from repeated handling . . . yellowed and dirty with age? CRONAFLEX makes them like new again, adding the extra benefit of durability! And you can do the whole job in a single, easy step because CRONAFLEX Direct Positive Film requires no negative! Modifications can be made at any time, thanks to its excellent drafting surface.

Direct Positive is just one of Du Pont's complete line of CRONAFLEX Engineering Reproduction and Drafting Films. To learn more about these products and how they can make your operation more efficient, clip and mail the coupon today.

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BETTER THINGS FOR BETTER LIVING . . . *THROUGH CHEMISTRY*

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The fastest d-c motor response... with new fan cooled Life-Line H motors

On-the-line test results (at the right) conclusively show the faster response of 30 hp d-c Life-Line H fan-cooled motors with these design improvements:

- 75% reduction in armature inertia
- 500% commutating ability for accelerating
- 30% reduction in electrical time constant

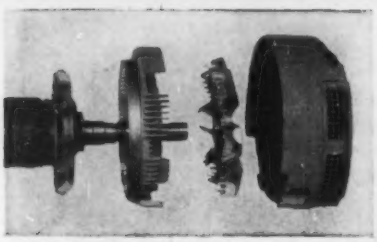
Similar motor performance throughout the line provides faster starts, quicker stops, faster reversing, precise regulation of speed and torque. This enables you to increase production, improve product quality and eliminate costly processing complications.

The unique cooling system combines a built-in heat exchanger with air-over-the-motor ventilation which permits smaller frame sizes per horsepower delivered. Result: less mounting space; less weight.

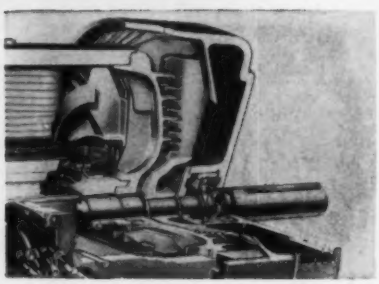
In addition, this rugged TEFC Life-Line H motor offers many other advantages:

- Screened air intakes, cast end brackets, and tight seals throughout provide resistance to liquids, vapors, dirt and dust.
- Self cleaning fan eliminates the possibility of clogging or fouling.
- Location of bearing and the outboard bracket increases bearing life when load is belt-driven.
- Uniforce* brushholder assembly automatically maintains constant brush pressure throughout the normal life of the brush.

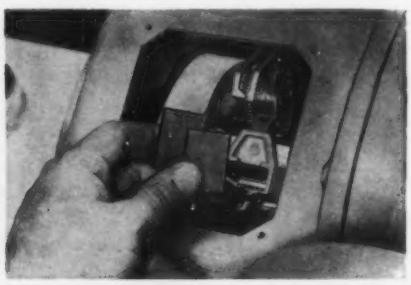
*Trademark



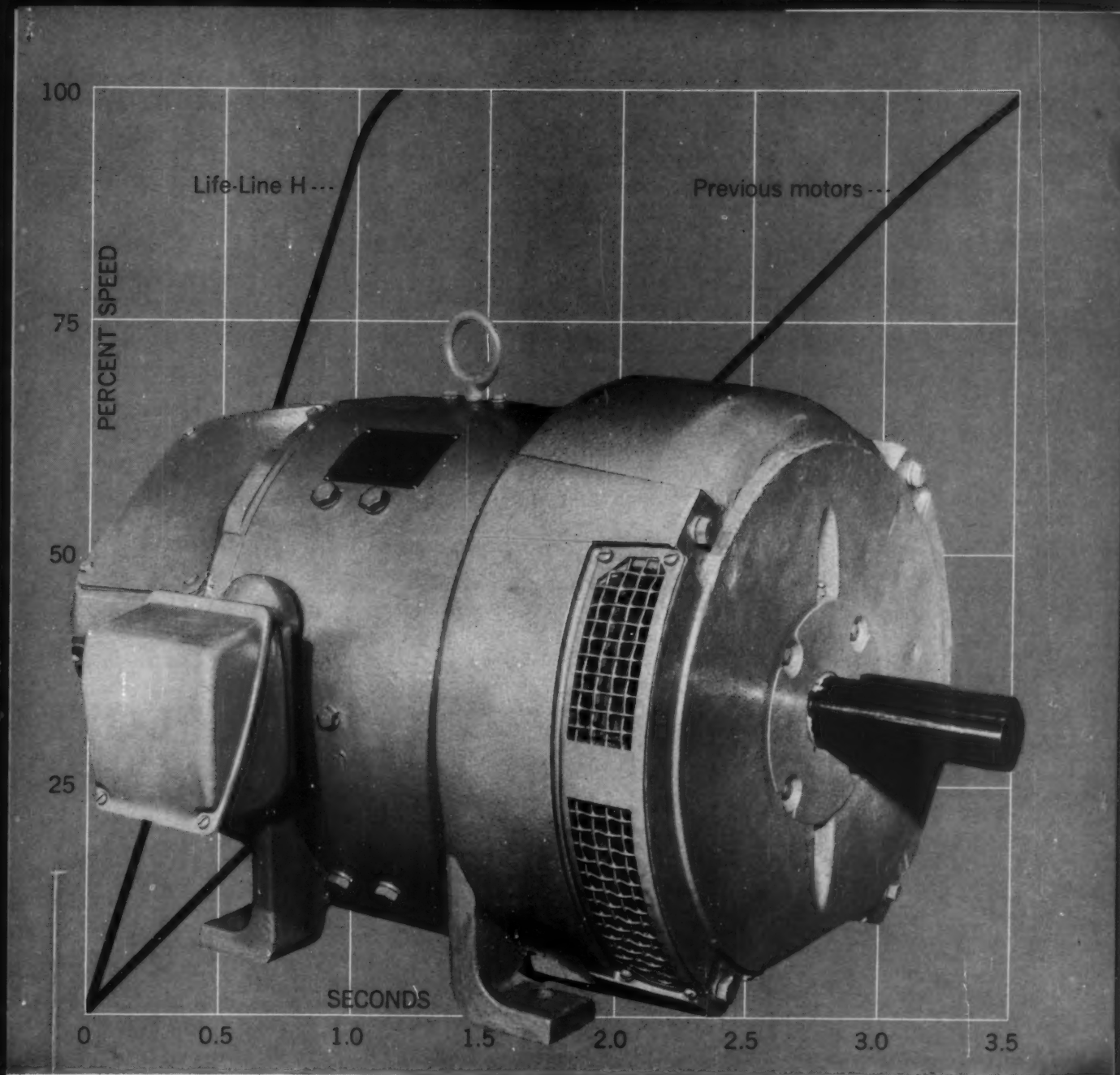
UNRESTRICTED AIR FLOW . . . The internal fan creates an air flow which directs internal heat to the aluminum heat exchanger. The external fan draws air through the bracket bottom and side openings, cooling the total surface of the heat exchanger. The air continues unrestricted over the frame for additional cooling. The meshing action of the fan and heat exchanger fins provide self cleaning action as demonstrated above.



OUTBOARD BEARING LOCATION, LONGER LIFE . . . Exclusive outboard bearing construction keeps foreign matter out. Bearing-to-load position remains the same as in drip-proof motors for longer bearing life and less possibility of shaft breakage under any load condition.



LOCK OUT BRUSHHOLDERS . . . Uniforce brushholder fingers lock-out . . . brushes can be inspected or changed with one hand. Tension remains constant throughout brush life, no need to adjust pressure as brushes wear. This field proven design also provides smooth brush ride and continuous contact for sparkless commutation.



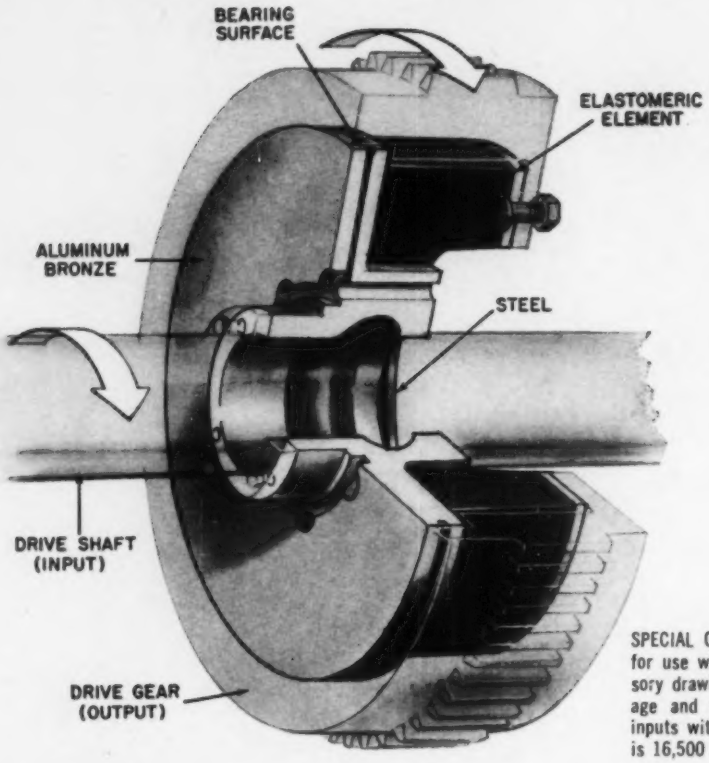
Your Westinghouse motor specialist is equipped with full information on how this fast acting d-c motor will fit into your production scheme. Call him for help on specific applications, or write Westinghouse Electric Corporation, 3 Gateway Center, P.O. Box 868, Pittsburgh 30, Pa.

You can be sure . . . if it's Westinghouse.

J-22169

Westinghouse

CIRCLE 31 ON READER SERVICE CARD



SPECIAL COUPLING was designed by Lord for use with gear in diesel engine accessory drawing. It protects gears from damage and wear by isolating 8° torsional inputs with 98% efficiency. Torque rating is 16,500 in.-lbs. at 850 rpm.

DESIGN FOR SMOOTH POWER FLOW

with custom-engineered

Lord Flexible Couplings

Torsionally resilient couplings offer important operating advantages for many power transmission applications. Here's what Lord can give you in a special flexible coupling:

Custom design. Couplings can be designed to meet any specific requirements. They can incorporate any degree of flexibility in one or more modes. Elastomers can be specially compounded to resist extreme temperature and oil environments.

Smooth power flow. Lord Couplings provide constant speed transmission of power with no backlash. Torsional disturbances are efficiently isolated. Varying degrees of misalignment—angular, parallel, axial—can be accommodated simultaneously.

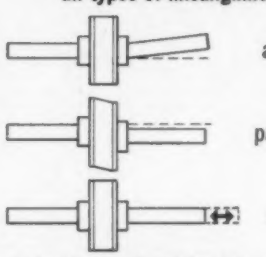
Reliability. Simplified design—no gears, seals, bearings or metal-to-metal contact—assures long service life. Resilience protects driven equipment from damaging inputs and extreme overloads.

Special features. Torque capacities from inch-ounces to foot-tons. Permanently quiet operation. Attenuation of shaft-borne noise. No lubrication or maintenance. Minimum size for given horsepower. Optional fail-safe protection.

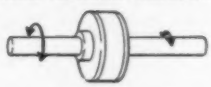
Package assembly. All these features can be incorporated in a special coupling designed by capable, experienced engineers. Your custom couplings will arrive precision produced, fully tested, ready to do your job.

Get more details from your nearest Lord Field Engineering Office or the Home Office, Erie, Pa.

Lord Flexible Couplings accommodate all types of misalignment:



. . . and isolate torsional vibration and shock:



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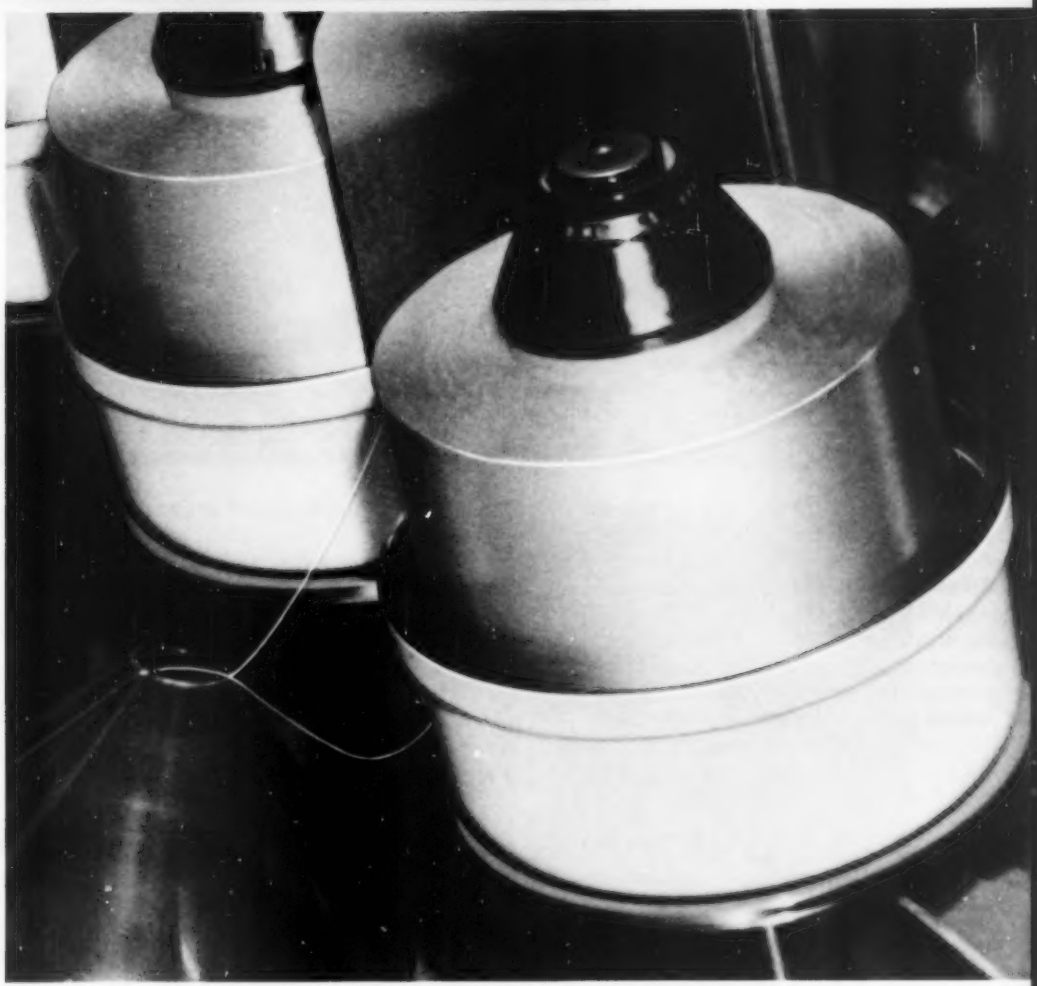
"In Canada—Railway & Power Engineering Corporation Limited"

LORD MANUFACTURING COMPANY · ERIE, PA.

working with Du Pont Delrin®

one of Du Pont's versatile engineering materials



New textile supply buckets of DELRIN® last longer... cost less

Large (10 in. diameter, 1¼ lbs.) buckets economically injection-molded of Du Pont DELRIN acetal resin provide Leesona Corporation, Providence, R. I., with a rugged, long-wearing part for their heavy-duty textile machinery.

Evenly wound packages of filament yarn sit within the buckets of DELRIN (shown above) on a multi-spindle Twister-Coner machine. This machine transfers the yarn from the evenly wound spools to cones at a rate of 340 yards per minute.

The bowl-shaped buckets (molded by Crystal Thermoplastics, Inc., Pawtucket, R. I.) are stationary and thus are subject to abrasion and static build-up by friction of the moving yarn. DELRIN resists both—in fact, outwears phenolic resins previously used—and, in addition, DELRIN maintains its dimensional stability in dry or humid environment.

DU PONT

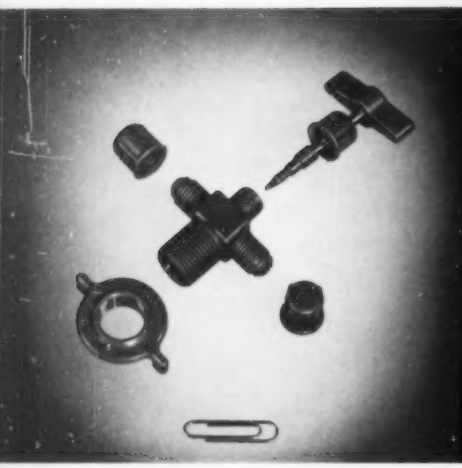
REG U.S. PAT. OFF.

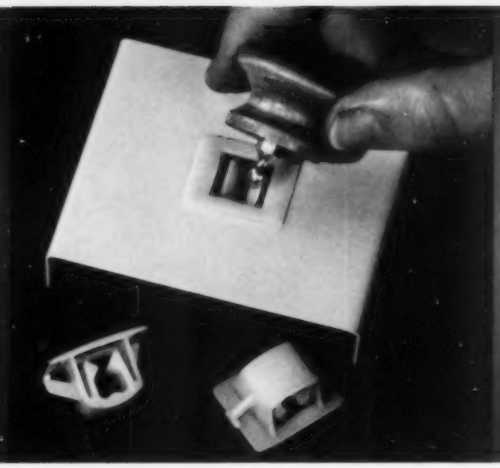
BETTER THINGS FOR BETTER LIVING ... THROUGH CHEMISTRY

working with

Du Pont Delrin®

one of Du Pont's versatile engineering materials





CAN TAP VALVE for use with packaged refrigerant containers is molded entirely of DELRIN except for piercing needle. Molded-in threads are strong and clean; caps fit tightly. Parts molded of Du Pont DELRIN do not corrode and maintain their dimensions under a wide range of temperatures and humidity. (Molded by Industrial Plastic Molders, Inc., for Watsco, Inc., both of Hialeah, Florida.)

CABINET CATCHES molded of DELRIN take advantage of the resilient, spring-like properties of this resin to permit easy installation of the catch and to hold the steel strike. Abrasion and fatigue resistance of DELRIN allow long life under repeated cyclic stressing of the retaining fingers. Its natural lubricity permits steel strike to move smoothly. (Made by Amerock Corp., Rockford, Ill.)

LAWN SPRINKLERS molded of tou Du Pont DELRIN resist abrasion fr sand and silt. DELRIN offers excell resistance to corrosion and "lime-u trouble-free service, excellent thre strength. And a choice of colors is ma possible by the integral colors of DEL acetal resin. (Molded by Lee Deane P ducts, Inc., for Plasmet Engineering C both of Santa Fe Springs, California.)

DELRIN has strength and toughness

to function reliably under rugged usage. Parts molded of Du Pont DELRIN acetal resin retain a high degree of their mechanical properties under severe environmental conditions, such as high temperatures, moisture, solvents and many corrosive chemicals.

Many designers are taking advantage of the wide range of unique properties of DELRIN, and the substantial cost economies in manufacture and assembly. Why not investigate the possibilities of DELRIN for your product? Mail the coupon below for more information.

POLYCHEMICALS DEPARTMENT

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. . . THROUGH CHEMISTRY

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Nemours Building, Wilmington 98, Delaware

I am interested in evaluating DELRIN for the following use:

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*Name*_____

*Company*_____ *Position*_____

*Street*_____

*City*_____ *Zone*____ *State*_____

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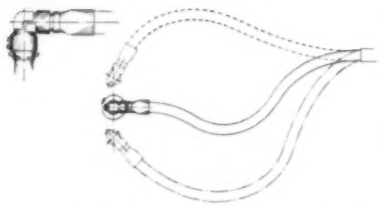
DELRIN® *acetal resins*

one of Du Pont's versatile engineering materials

Alathon® · Zytel® · Lucite®

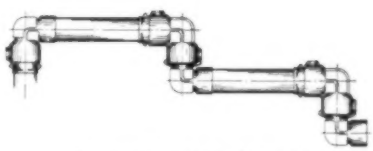
HERE ARE 3 COMMON LINE DESIGN PROBLEMS CHIKSAN SWIVEL JOINTS CAN HELP YOU SOLVE

1 **Shorten hose radii, reduce torsional stress.**



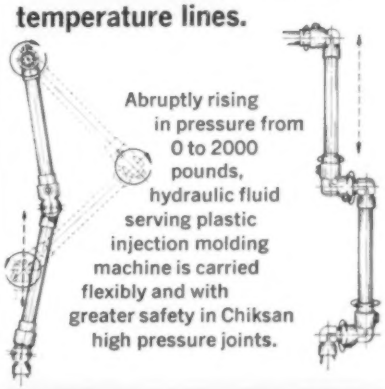
Flexible head on this lens grinder is hydraulically powered. Joints shorten required hose lengths. Hose would otherwise need suspension to keep out of way.

2 **Predetermined flex of piping between two or more points.**

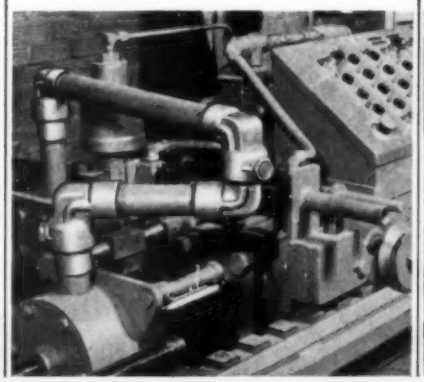


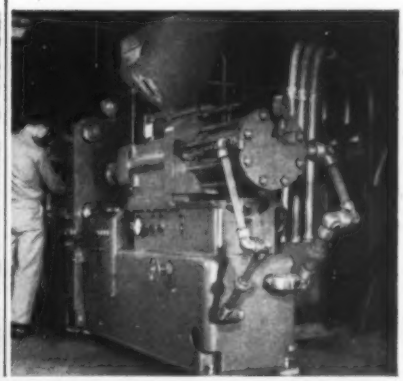
Pressure testing of pipe is nearly automatic as hydraulically driven supply heads close on pipe ends. Dog-leg jointed pipe moves back and forth continuously, safely.

3 **Achieve maximum safety of flexible high pressure, temperature lines.**



Abruptly rising in pressure from 0 to 2000 pounds, hydraulic fluid serving plastic injection molding machine is carried flexibly and with greater safety in Chiksan high pressure joints.





Studied consideration will quickly show that Chiksan swivel joints have numerous applications. Whenever you have a piping situation where movement is required, the benefits of swivel joints should be weighed. As illustrated above, Chiksan swivel joints have great versatility. They give added life and adaptability to rubber hose. They give metal lines a rubber-like flexibility. They help relieve stresses imposed by expansion, vibration or misalignment. Chiksan swivel joints, with their full 360° rotation and high service life, quickly pay for themselves by minimizing hose failures, eliminating costly line failures, fluid loss and downtime. Chiksan swivel joints have a wide range of pressure and temperature ratings to meet most industrial applications. There is a nearby experienced representative who will call, analyze your requirement and make specific recommendations. Write today for his name.

#61-64

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Please send me a copy of your catalog and the name of your nearest representative.

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CHIKSAN COMPANY—General Offices: Brea, California • Well Equipment Mfg. Corp. Division (Weco Unions, Homer Valves) • Chiksan International • Chiksan of Canada Ltd. Offices and Representatives in Principal Cities of the World

Post-Forming: New Way to Bigger Savings with Malleable Castings

The ductility of Malleable iron castings permits use of high-speed forming techniques to finish Malleable parts at lower cost. Take advantage of the versatility you get only with ferritic and pearlitic Malleable castings. For a fuller understanding of how Malleable can help you, call any producer that displays this symbol —

Free Folder describing these techniques is available for your use. Just ask any member of the Malleable Castings Council for Data Unit No. 116, or write to Malleable Castings Council, Union Commerce Building, Cleveland 14, Ohio.

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MALLEABLE
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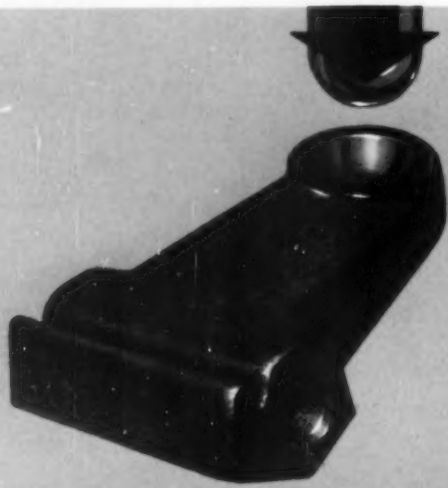
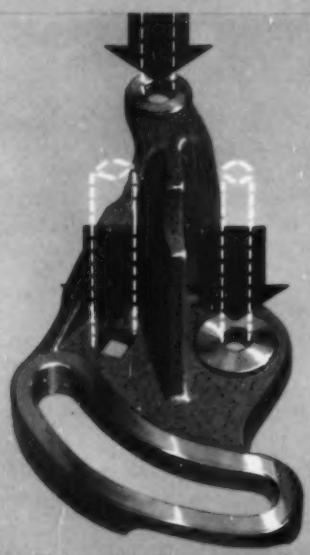


Hot Form It — Hot coining this Malleable transmission part reduces finished cost . . . eliminates three cutting operations required by the previously used steel part.

Roll It — Oil grooves in lawnmower crankshafts and splines in compressor crankshafts are just two of many places where rolling proves more economical than machining.



Punch It — Holes with diameters greater than the thickness of the metal can be punched in Malleable. Two round holes and a square hole are punched simultaneously in this idler arm.

Spin It — Malleable's ductility permits the sleeve and end disc in this ball joint to be held in place by spinning the Malleable housing into a strong, permanent flange.

Get the most for your metals dollar...get MALLEABLE

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Connecticut Mall. Castings Co., New Haven 6
Alloy Foundries Division, The Eastern Co., Naugatuck

ILLINOIS
Central Fdry. Div., Gen. Motors, Danville
Chicago Malleable Castings Co., Chicago 43
Moline Iron Works, Moline
Moline Malleable Iron Co., St. Charles
National Castings Co., Cicero 50
Peoria Malleable Castings Co., Peoria 1
Wagner Castings Company, Decatur

INDIANA
Albion Malleable Iron Company, Muncie Division, Muncie
Link-Belt Company, Indianapolis 6
National Castings Co., Indianapolis 22

IOWA
Iowa Malleable Iron Co., Fairfield

MASSACHUSETTS
Belcher Malleable Iron Co., Easton

MICHIGAN
Albion Malleable Iron Co., Albion
Auto Specialties Mfg. Co., Saint Joseph
Cadillac Malleable Iron Co., Cadillac
Central Fdry. Div., Gen. Motors, Saginaw

MINNESOTA
Northern Malleable Iron Co., St. Paul 6

MISSISSIPPI
Mississippi Malleable Iron Co., Meridian

NEW HAMPSHIRE
Laconia Malleable Iron Co., Laconia

NEW YORK
Acme Steel & Mall. Iron Works, Buffalo 7
Frazer & Jones Company Division, Eastern Malleable Iron Co., Solvay
Oriskany Malleable Iron Co., Inc., Oriskany
Westmoreland Mall. Iron Co., Westmoreland

OHIO
American Malleable Castings Co., Marion
Central Fdry. Div., Gen. Motors, Defiance
Dayton Mall. Iron Co., Ironton Div., Ironton
Dayton Mall. Iron Co., Ohio Mall. Div., Columbus 16
National Castings Co., Cleveland 6

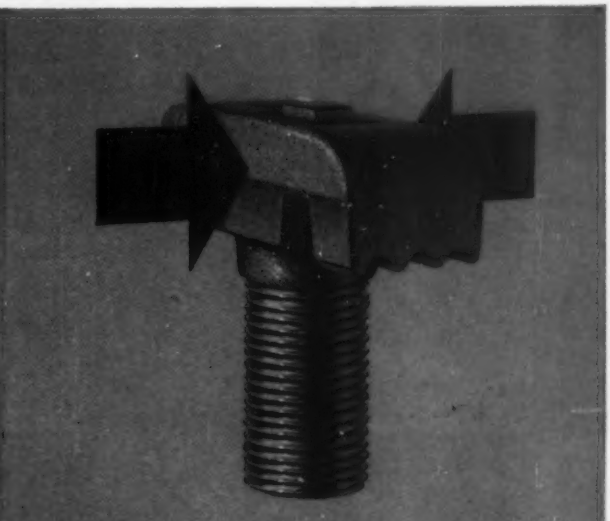
PENNSYLVANIA
Buck Iron Company, Inc., Philadelphia 22
Erie Malleable Iron Co., Erie
Lancaster Malleable Castings Co., Lancaster
Lehigh Foundries Company, Easton
Meadville Malleable Iron Co., Meadville
Pennsylvania Malleable Iron Corp., Lancaster

TEXAS
Texas Foundries, Inc., Lufkin

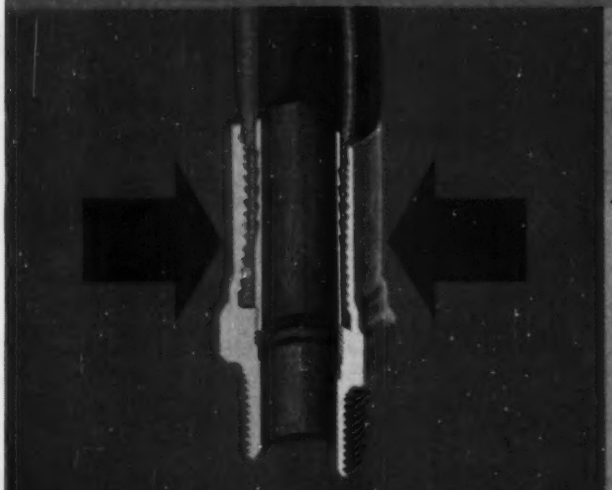
WEST VIRGINIA
West Virginia Mall. Iron Co., Point Pleasant

WISCONSIN
Belle City Malleable Iron Co., Racine
Chain Belt Company, Milwaukee 1
Federal Malleable Company, Inc., West Allis 14
Kirsh Foundry Inc., Beaver Dam
Lakeside Malleable Castings Co., Racine
Milwaukee Malleable & Grey Iron Works, Milwaukee 46

Bend It — A 30% cost reduction was achieved by casting this Malleable iron twine finger flat . . . then bending the arm about 45 degrees and coining the center hub in one fast, post-forming operation.



Coin It — Very close tolerances are often met economically by either cold or hot coining. The head of this T-bolt is coined to meet tolerances of ± .005" on its .475" width without any machining.



Swage It — Long trouble-free service is built into this high-pressure hose coupling by swaging the Malleable fitting around the reinforced hose in a 15-ton press. It's fast, permanent and economical. Working pressure of the hose is 2,000 psi.

Harden It — Surface hardness values in excess of 55 Rockwell C can be achieved with pearlitic Malleable by either flame or induction hardening. Response is excellent, and results are uniform.

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PROBLEM-SOLVING KNOW-HOW AND EXPERIENCE have made Republic a leader in custom production of Fastener and Formed Parts "Specials." Whenever standard fasteners can't do the job, you'll save time and money by contacting Republic. Write for data on Republic design, engineering, and production services.

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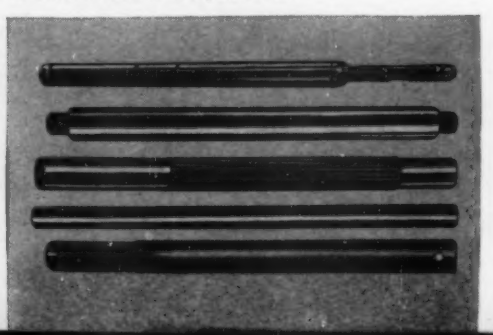
Steel

Strong, Modern, Dependable



World's Largest Producer of SPECIALTY WELDED TUBING

Challenge us to come up with a solution to your toughest tubing applications.

We will produce the best possible answer drawn from Republic's full line of quality welded steel tubing and more than 50 years of applied engineering experience.

This claim is made with confidence. Our customers regularly hand us their tubing problems, and the results have provided mutual satisfaction.

Manufactured at the Steel and Tubes Division, Republic Tubing is welded by the ELECTRUNITE® process—a continuous electric weld method which unites the wall under pressure without foreign or extra metal. Among other advantages, this process assures uniformity of wall thickness, strength, ductility, and concentricity.

Republic, the pioneer in this improved welding process, was also the first to provide a non-destructive electronic production method of testing tubing used for critical pressure applications. This is known to the trade as FARROWTEST®.

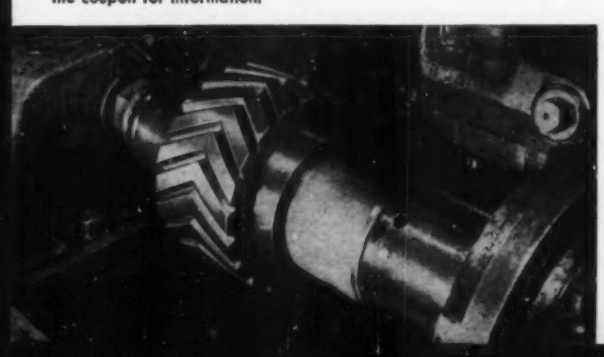
Next time you have a tubing application or problem, take advantage of Republic's prompt delivery, engineering services, and complete range of carbon and stainless steels for mechanical, structural, and pressure uses.

Call your nearest Steel and Tubes representative or contact us direct.

REPUBLIC STEEL

REPUBLIC HAS THE FEEL FOR MODERN STEEL

FOR ADDED MACHINABILITY, consider Republic Cold Drawn Leaded Alloy Steels. Leading producers of gears use Republic Leaded Alloy Steel in the manufacture of heavy-duty herringbone gears. Addition of lead increases machinability as much as 25%. Heat treating assures adequate hardness and toughness. Cost-reducing Republic Alloys are available in almost every standard analysis and many specials. Mail the coupon for information.



Check this listing of Republic Steel Tubing and Pipe. Which have possible applications in your products?

STAINLESS STEEL

Pressure Tubing

- ☐ Condenser Tubes
- ☐ Pipe—Schedule 40S
- ☐ Sanitary Tubes
- ☐ Heat Resistant
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CARBON STEEL

Pressure Tubing

- ☐ Boiler Tubes
- ☐ Heat Exchanger Tubes
- ☐ Hydraulic Fluid Line
- ☐ Grooved End Tubes
- ☐ Refrigerator Tubes
- ☐ Water Wall Tubes
- ☐ Superheater Tubes
- ☐ Condenser Tubes
- ☐ Evaporator Tubes

Mechanical Tubing

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Cut out and send this check list for descriptive literature on Republic Tubing and Pipe applicable to your products.

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- ☐ Republic Alloy Steels
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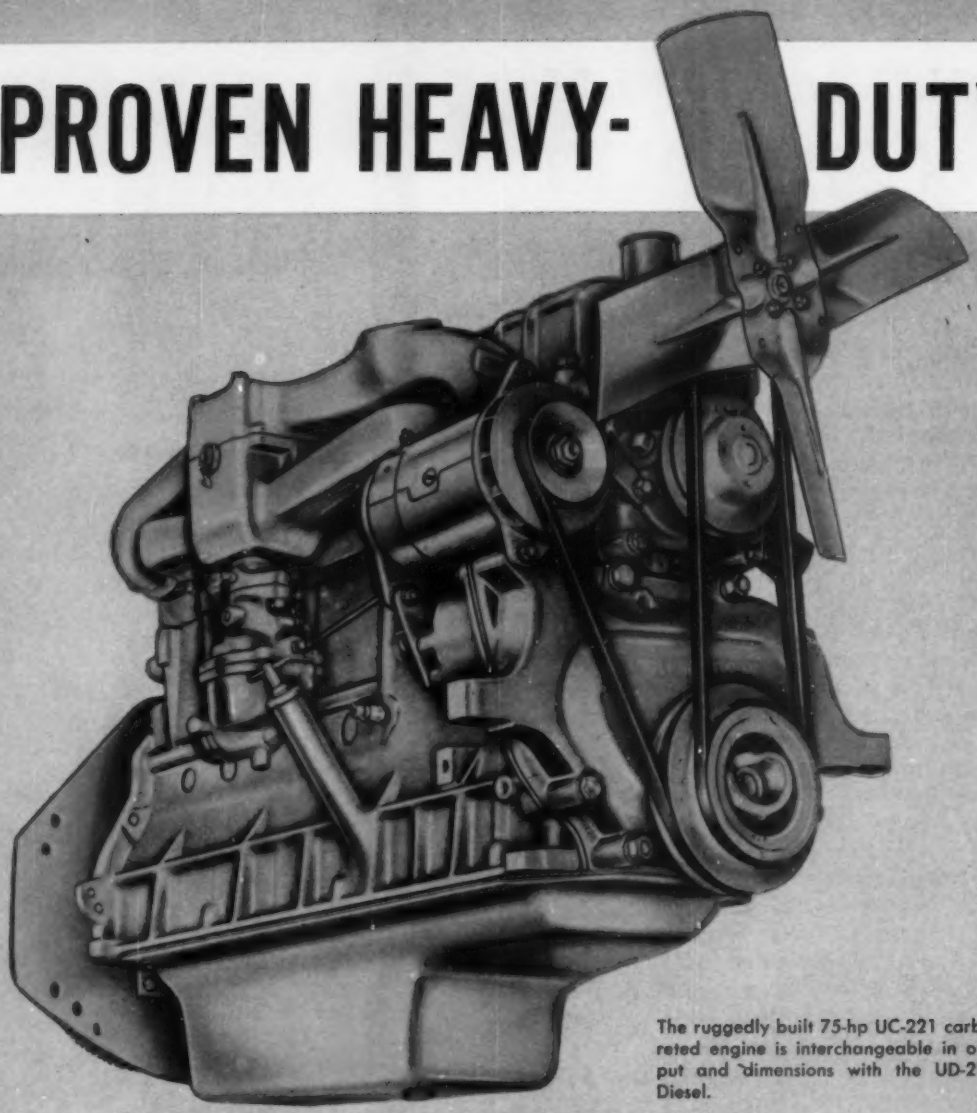
JOB-PROVEN HEAVY-DUTY



The ruggedly built 75-hp UC-221 carbureted engine is interchangeable in output and dimensions with the UD-236 Diesel.

BRIEF SPECIFICATIONS

ENGINE MODEL	DISPL. IN.	BORE, STROKE	LENGTH	WIDTH	HEIGHT	WEIGHT	FUEL	ENGINE HP @ RPM	POWER UNIT HP @ RPM
UC-263	263	3 3/16 x 4.39	41 1/32	23 7/16	30 21/32	895	GASOLINE	95 @ 2400	91 @ 2400
							L.P.G.	89 @ 2400	82 @ 2400
							NAT. GAS	80 @ 2400	74 @ 2400
UC-221	221	3 3/16 x 3 11/16	41 1/32	23 7/16	30 21/32	895	GASOLINE	75 @ 2400	71 @ 2400
							L.P.G.	73 @ 2400	69 @ 2400
							NAT. GAS	65 @ 2400	60 @ 2400
UD-282	282	3 11/16 x 4.39	41 3/16	23 45/64	30 9/32	905	DIESEL	95 @ 2400	90 @ 2400
UD-236	236	3 11/16 x 3 11/16	41 3/16	23 45/64	30 9/32	905	DIESEL	75 @ 2400	70 @ 2400

INTERCHANGEABLE POWER!

International brings you interchangeable diesel and carbureted engines in the 75-95 hp range...

These four International engines give you great design flexibility in a popular horsepower range. Interchangeable in size and power, two 75-hp and two 95-hp models give you a choice of diesel or carbureted operation. Factory-installed carburetors on the UC-221 and UC-263 equip these models to efficiently burn gasoline, LP gas or natural gas. The UD-236 and UD-282 incorporate the same features of economy and dependability that have made IH diesels famous. All four engines feature International's sure-fire push-button starting, full-length water jackets, and efficient thermostatic cooling.

Carbureted engines with diesel ruggedness!

Carbureted models are built with the same heavy-duty construction you find in the diesel engines. Many parts are interchangeable—counterbalanced 4-bearing crankshaft, deep I-block crankcase, long-life tri-metal bearings, heat-treated steel connecting rods, gear-driven induction hardened camshafts—all are built with diesel ruggedness, to add extra years to your carbureted power. This feature also cuts costs on maintenance and replacement parts.

Diesel engines at carbureted prices!

Interchangeability permits standardization of many parts and fixtures, and consequently promotes notable savings in the manufacture of these engines. The savings are passed along to you, and the result is a diesel engine—fully designed for heavy-duty diesel operation—at a price you would expect to pay for a lighter "automotive" model.

The complete IH line—62 engines from 8 to 385 max. hp—offers the greatest number of models, with the widest flexibility, in the most usable horsepower range. Find out today how International's progressive engineering techniques and wide power range can help you solve design problems in your products. Call or write to International Harvester Co., Engine Sales Dept., Melrose Park, Ill.

INTERNATIONAL®

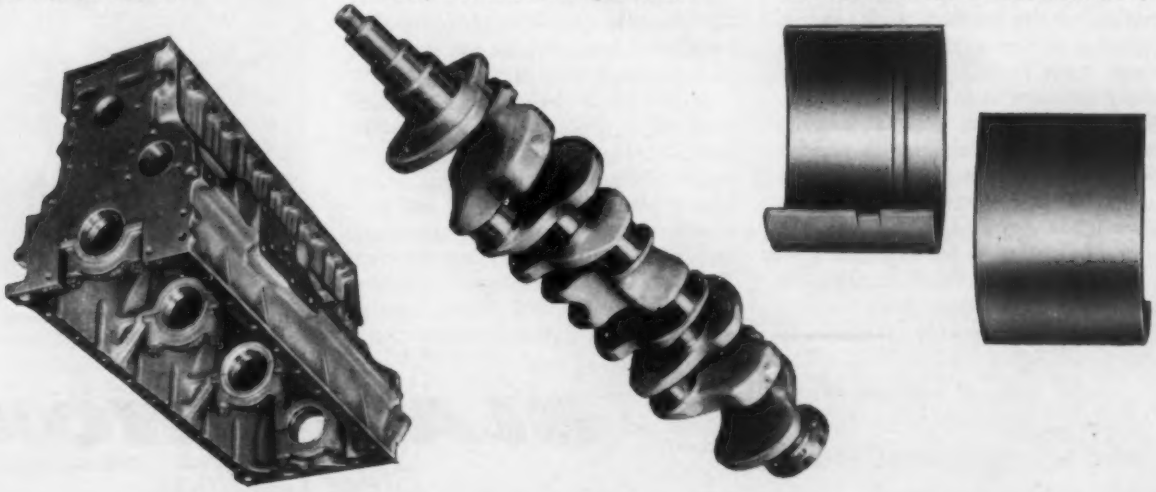
ENGINES

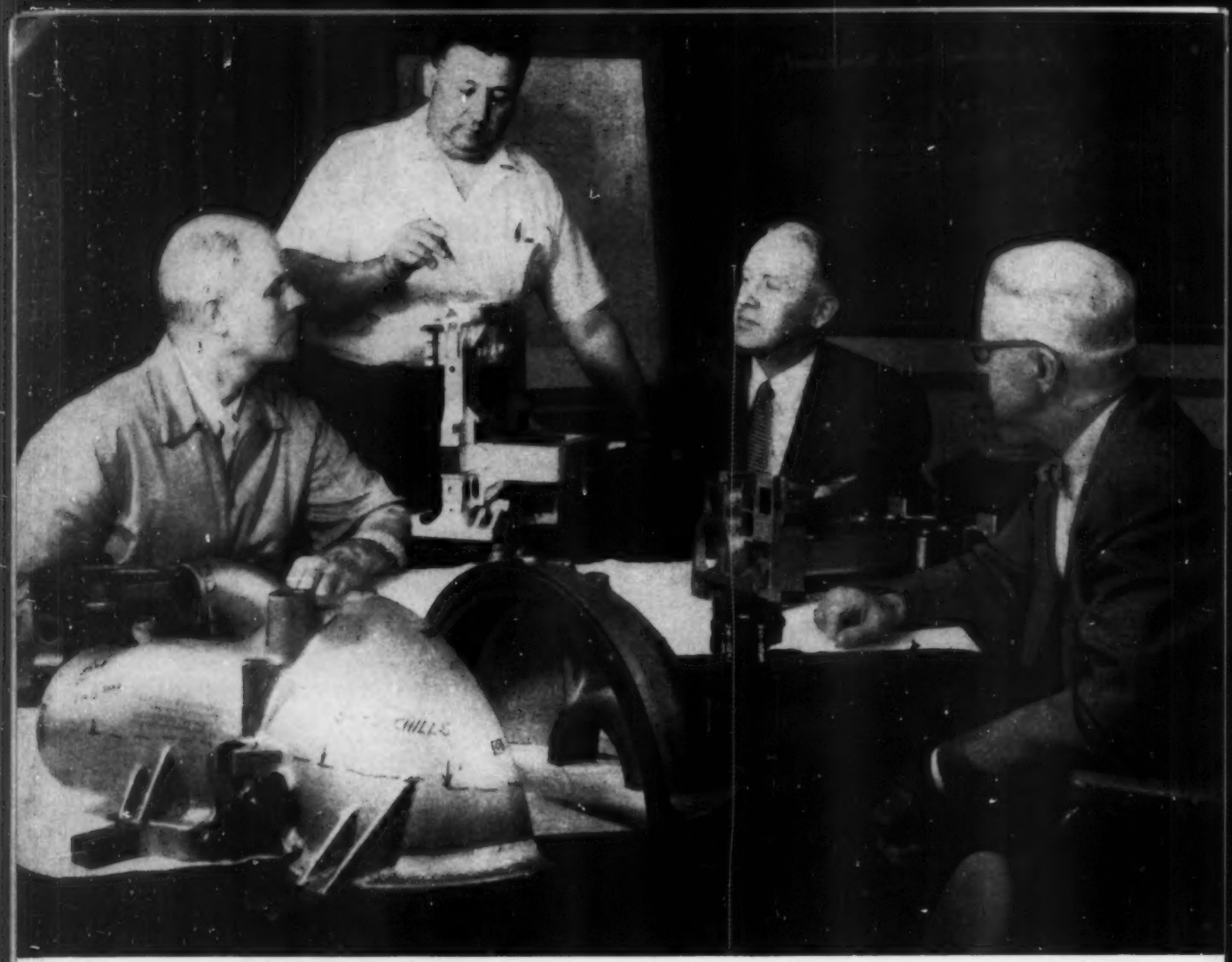
International Harvester Co.,
180 North Michigan Ave., Chicago 1, Ill.
A COMPLETE POWER PACKAGE

Deep I-block crankcase is common to both carbureted and diesel engines. Heavy ribs and extended construction (well below level of bearing caps) gives strength where it's most needed.

Counterbalanced crankshaft and fully machined combustion chambers produce super-smooth 6-cylinder power. Crankshaft has four high capacity main bearings and is fully hardened for longest service.

Tough tri-metal construction for connecting rod and main bearings—steel back, copper-lead center, babbit overlay—produces unmatched load carrying capacity, and adds thousands of hours of service.



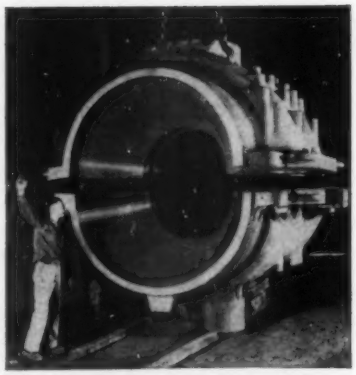


Design assistance from Blaw-Knox can cut unnecessary weight, improve the service life of your product

One of the ways in which the skill of experienced Blaw-Knox steel foundrymen can be first applied to your product is in the construction of scale models of the finished steel casting. Coming at the preliminary design stage, scale models permit intensive study of ways of improving quality, eliminating weight, and minimizing machining. This design study, coming before master patterns are made, is conducted to uncover ways in which Blaw-Knox can add to the value of your product or reduce its cost.

This practical design analysis, a feature of Blaw-Knox Steel Casting Service, is of invaluable assistance to designers and manufacturers. And because Blaw-Knox, itself, is one of the world's leading manufacturers of rolling mills and industrial machines, its steel foundrymen, from patternmaker to shipper, keep end-use requirements in mind every step of the way.

If you are a designer or manufacturer of a product using cast steel components, ranging from 50 pounds to 300,000 pounds, Blaw-Knox would like to send you a copy of our brochure which details the complete Blaw-Knox Steel Casting Service. Write to the Foundry and Mill Machinery Division, 300 Sixth Avenue, Pittsburgh 22, Pennsylvania.



This upper and lower cylinder blade ring for a steam turbine was cast and machined by Blaw-Knox. Weight—55,000 pounds per half.

BLAW-KNOX

Steel Castings

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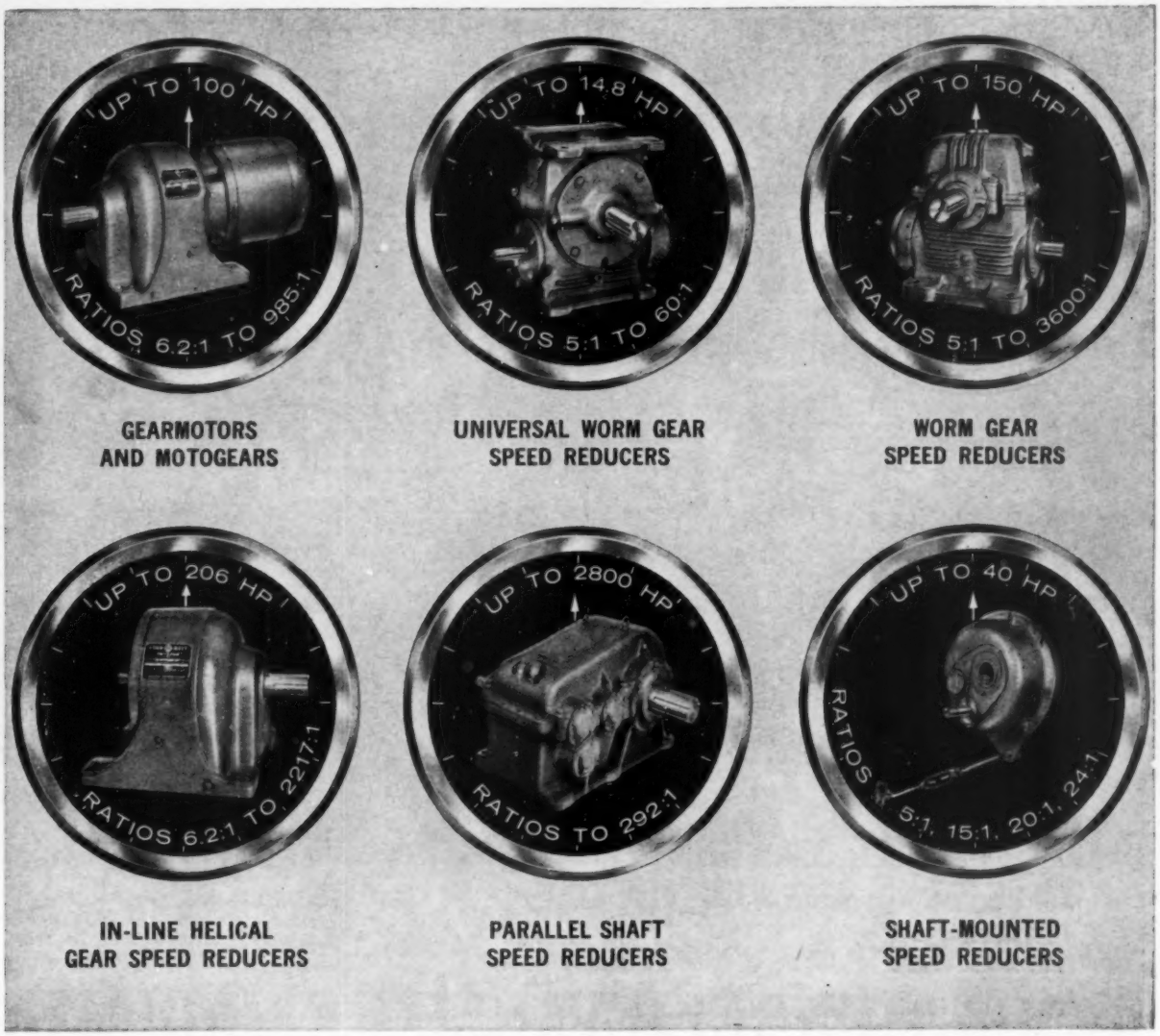
CIRCLE 42 ON READER SERVICE CARD

LINK-BELT SPEED REDUCERS . . .

geared for every speed and need


UP TO 100 HP
RATIOS 6.2:1 TO 985:1
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UNIVERSAL WORM GEAR SPEED REDUCERS
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UP TO 206 HP
RATIOS 6.2:1 TO 2217:1
IN-LINE HELICAL GEAR SPEED REDUCERS
UP TO 2800 HP
RATIOS TO 292:1
PARALLEL SHAFT SPEED REDUCERS
UP TO 40 HP
RATIOS 5:1, 15:1, 20:1, 24:1
SHAFT-MOUNTED SPEED REDUCERS

industry's most comprehensive speed reducer line!

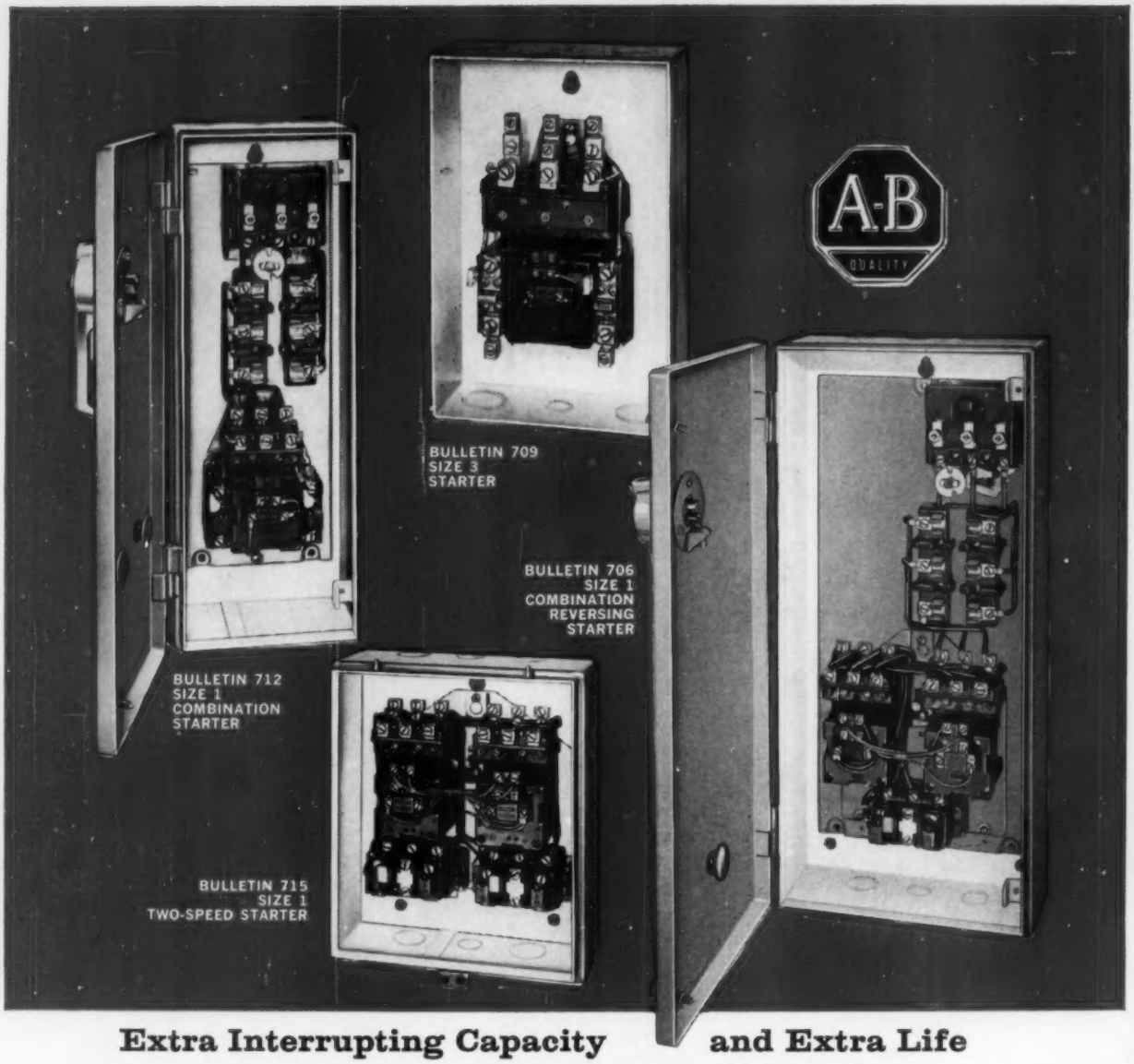
With Link-Belt's broad line to choose from, you can plan *any* speed reduction setup . . . exactly meet your requirements for ratio, space, shaft position, shock loading and other service factors. Link-Belt's seven basic types of speed reducers—each in a wide range of sizes and ratios—give you complete flexibility in drive layout.

There's another important advantage in calling on Link-Belt for your speed reduction needs. Link-Belt makes all related drive components—chains and sprockets, bearings, couplings—all dimensionally correlated with these reducers. This one-source service assures you of a smooth-working, perfectly matched set of equipment. No alignment problems . . . no need to exchange drawings with other suppliers.

See the Yellow Pages for your nearest Link-Belt office. Look under "Speed Reducers." Ask for catalogs on any or all of the speed reducers shown above.

LINK-BELT

LINK-BELT COMPANY: Executive Offices, Prudential Plaza, Chicago 1. To Serve Industry There Are Link-Belt Plants, Warehouses, District Sales Offices and Stock Carrying Distributors in all Principal Cities. Export Office, New York 7; Australia, Marrickville (Sydney); Brazil, Sao Paulo; Canada, Scarboro (Toronto 13); South Africa, Springs; Switzerland, Geneva. Representatives Throughout the World. 15,703



Extra Interrupting Capacity and Extra Life

Give New Allen-Bradley Motor Controls

ALMOST UNBELIEVABLE RELIABILITY

The extra interrupting capacity that's built into these revolutionary new starters enables them to operate with ease at maximum rated capacity for prolonged periods—and still have ample reserve for emergency or unusual operating conditions. As a result, these new Allen-Bradley starters give *almost unbelievable* reliability and long life—a precious benefit for the user!

Where space is a problem, this new line warrants your interest—especially in the Size 2 and higher ratings. You'll find that small size has not been obtained at the sacrifice of "quality" or generous wiring room. In addition to the unmatched performance, you'll be pleased with the modern appearance of the enclosures. Brooks Stevens, world famous industrial designer, has given them the "eye appeal" which spells "quality" to the buyer. Please write today for the full details in Publication 6100: Allen-Bradley Co., 1329 S. First Street, Milwaukee 4, Wisconsin.

ALLEN-BRADLEY | **Quality Motor Control**

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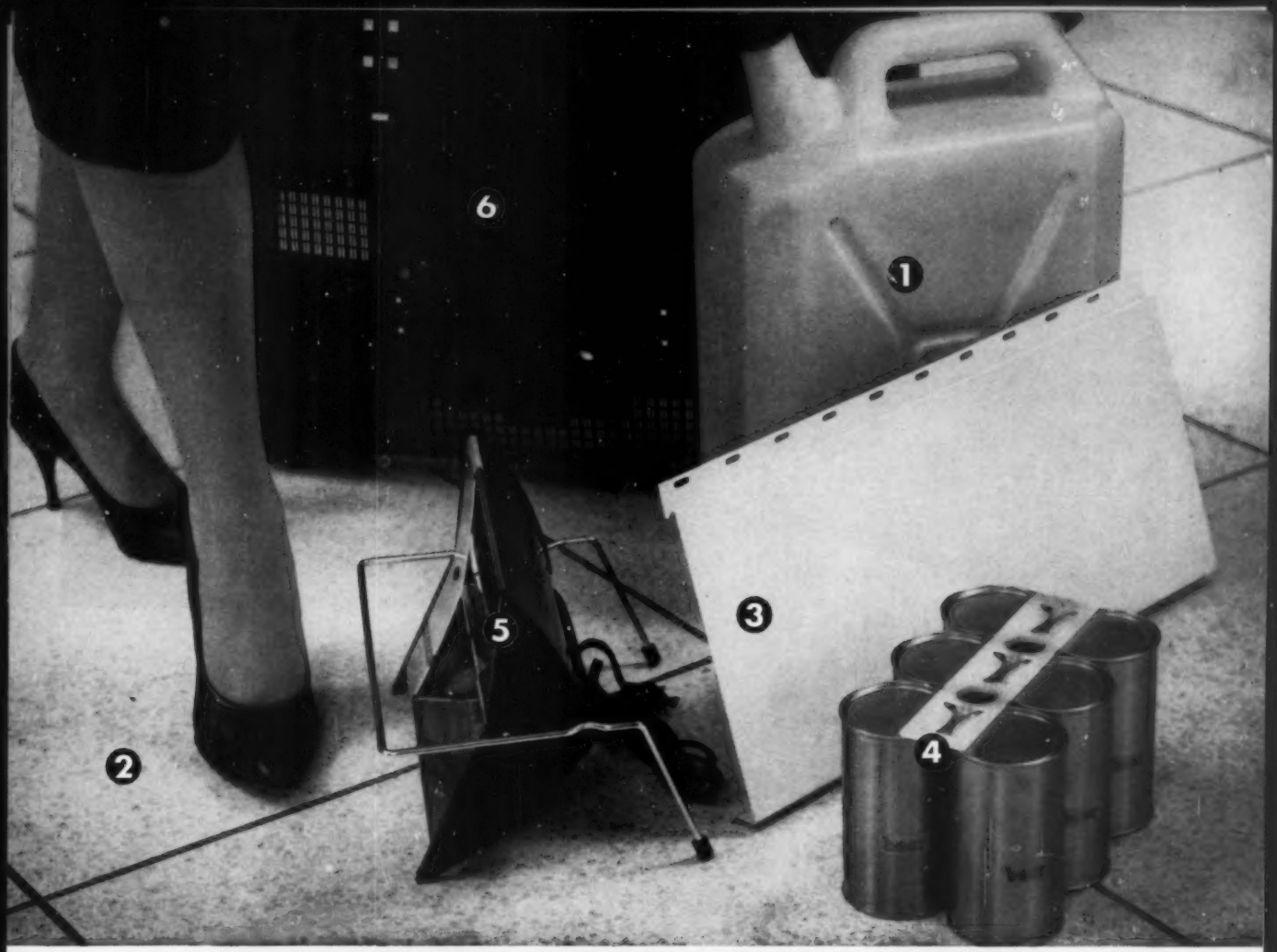


NEW DESIGN IDEAS IN PLASTICS

(Could one of them spark the solution to your problem?)

1 POLYETHYLENES—New lightweight container is ideal for a variety of liquids. Molded from BAKELITE high-density polyethylene, it is corrosion- and scuff-resistant. BAKELITE polyethylenes offer a broad range of properties: strength and sparkling clarity for film packaging, moisture- and grease-resistance for extrusion-coated packages, excellent insulating qualities for wire and cable, light weight for pipe.

2 EPOXIES—Epoxy terrazzo floors have more than twice the compressive strength of concrete terrazzo. Weight is cut 75% because ¼"-thick epoxy terrazzo equals performance of 1"-thick concrete-type. BAKELITE epoxies, among the strongest and hardest plastics known, are ideal for industrial coatings, adhesives, reinforced laminates (medium-to-long-run tools and dies).

3 VINYLS—Vinyl-based coatings on aluminum and steel are baked onto metal before forming. Provide excellent weather resistance with no cracking, chipping, or peeling. Offering high electrical resistance, formability, color and elastomeric qualities, BAKELITE vinyls can be easily fabricated into such products as swimming pool liners, extruded wire insulation, and as jacketing for conduits.

4 STYRENES—Beverage cans effortlessly snap on and off this handsome new 6-pack carrier made from BAKELITE medium-impact styrene. Styrenes offer the designer a wide range of impact strengths, brilliant colors, glowing finishes. Molded and extruded styrenes are ideal for toys, containers, housewares, refrigerator door liners, portable TV cabinets.

5 PHENOLICS—All-phenolic base housing for this newly designed sunlamp offers low heat conductivity, superior toughness. BAKELITE phenolics have high dimensional stability, very good machinability. Rich, glossy, smooth finishes. Ideal for all critical wet-dry conditions . . . and for bottle caps, chemical-resistant coatings, industrial or decorative laminates.

6 POLYPROPYLENES—High heat resistance plus light weight, toughness and excellent dielectric properties, make BAKELITE polypropylenes ideal for TV backs. Outstanding chemical-, fatigue-, and stress-cracking resistance make them well-suited for pipe, housewares, auto accessories, webbing for outdoor furniture and many other uses.

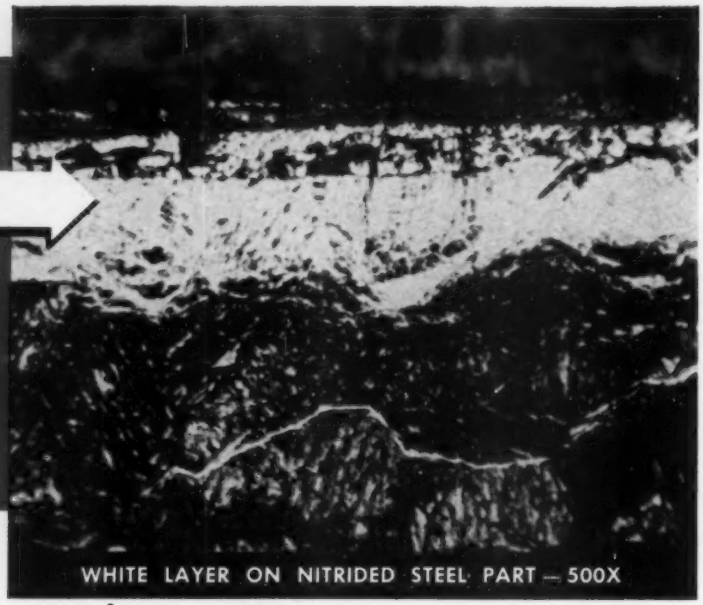
For information on application of these materials and processes to your products, write Dept. JW-113K, Union Carbide Plastics Company, Division of Union Carbide Corporation, 270 Park Avenue, New York 17, New York. Be sure to ask for your copy of the "Materials and Data Guide" which describes in detail the full range of BAKELITE Brand plastics.

UNION CARBIDE PLASTICS

BAKELITE and UNION CARBIDE are registered trade marks of Union Carbide Corporation.

CIRCLE 45 ON READER SERVICE CARD 45

REMOVE white layer FROM NITRIDED PARTS without grinding



WHITE LAYER ON NITRIDED STEEL PART — 500X

No longer is it necessary to grind the white layer off nitrided parts — gears, bearings, etc.

Now you can get rid of this blemish much more economically and without jeopardizing critical surfaces by grinding.

Your answer is BAN-WITE, a new metallurgical process (Pat. 2,960,421) developed by Red Ring Research.

This not only removes the objectionable white layer but it also tends to deepen the nitrided case. The danger of grinding checks is completely avoided.

Send your nitrided parts to us for treatment or, if you prefer, we will license you to use the process in your own plant. Either way, you save money and avoid rejects. Contact our local representative to get your jobs started now.

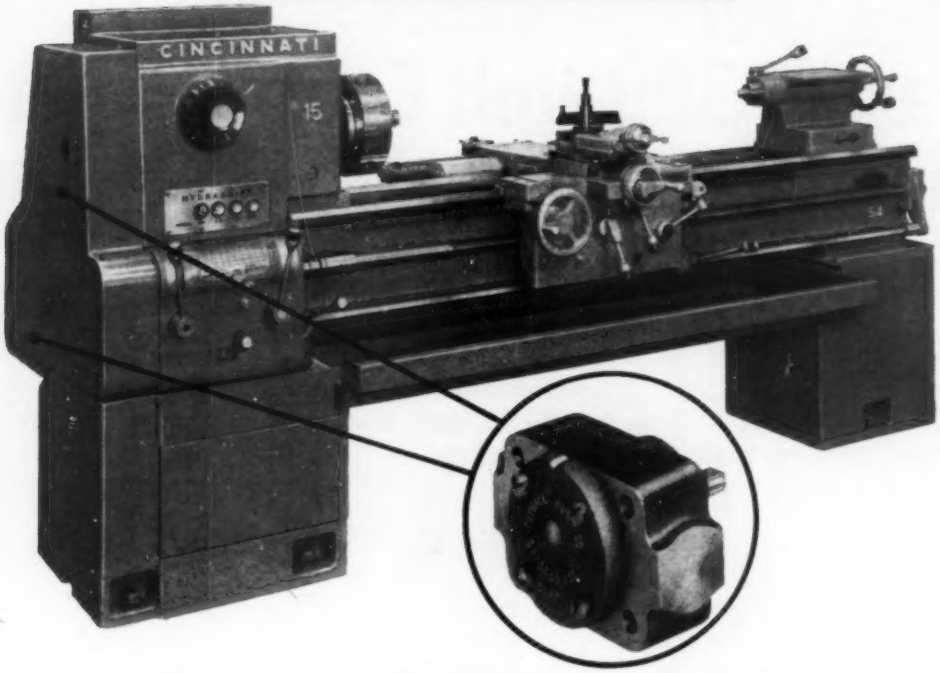
SAME PART AFTER BAN-WITE TREATMENT — 500X

WORLD'S LARGEST PRODUCER OF GEAR SHAVING AND HONING EQUIPMENT

NATIONAL BROACH & MACHINE CO.

5600 ST. JEAN • DETROIT 13, MICHIGAN

Another pump problem . . . solved by TUTHILL



TUTHILL PUMPS For Hydraulics, Lubrication in New Cincinnati Hydrashift Lathes

Cincinnati's new Hydrashift lathes use hydraulic power instead of muscle for spindle speed shifting. Entirely new from headstock to tailstock, these dependable units reflect in every way the quality and reliability long associated with this leading machine tool manufacturer.

Cincinnati selected Tuthill pumps for two vital assignments . . . to provide hydraulic power for Hydrashift preselective speed shifting . . . and for positive pressure lubrication of the entire unit. Minor modifications of a standard Tuthill cartridge pump, Series RFD, enable it to meet the requirements of both applications . . . providing interchangeability and allowing incorporation of both units with the greatest possible ease on Cincinnati's assembly line.

Wide Selection Available From Stock

Tuthill's versatile and dependable cartridge pumps have been used for hundreds of applications . . . both as OEM components and for maintenance. Their compactness solves design problems . . . for example the Model RFD above measures only $4\frac{1}{4}$" by $2\frac{1}{2}$" by $3\frac{15}{16}$" including shaft. Moderate prices and immediate availability from stock minimize inventory problems, result in significant savings.

Cartridge pumps can be supplied for capacities from 55 to 360 gph at 1800 rpm. They are available with or without Tuthill's special reversing feature which allows them to be driven from reversing shaft or for nondirectional service. They may be supplied with internal or external porting . . . or with variations of both. Three different standard shaft modifications are offered and many more are available.

Send today for Catalog 100 which gives complete details . . . or send information on your particular application so Tuthill's engineers can indicate ways in which a Tuthill pump can save you money.

Tuthill manufactures a complete line of positive displacement rotary pumps in capacities from 1 to 200 gpm; for pressures to 1500 psi; speeds to 3600 rpm.

PUMPS FOR YOUR PURPOSE

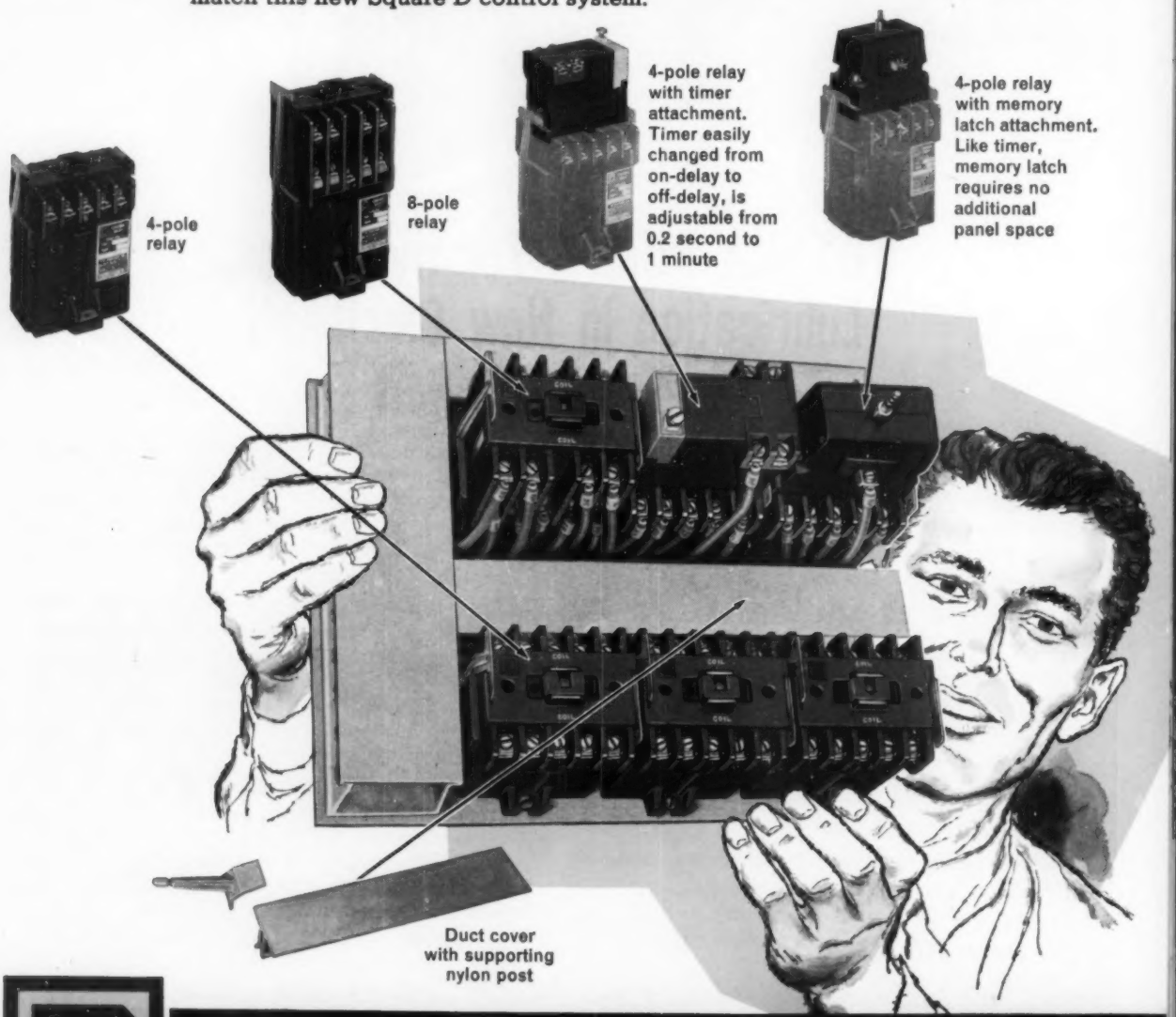
TUTHILL PUMP COMPANY

963 East 95th Street, Chicago 19, Illinois

CIRCLE 47 ON READER SERVICE CARD

NEW
Square D 300-volt Control System for Outstanding Versatility,

Here's the most advanced, easiest-to-use control system ever built! Just two basic relays plus two attachments (latching mechanism and timer) fill all your requirements. Square D's new 10-ampere **Type G relay** is small—has convertible contacts—can be disassembled in seconds without removing wiring—is manually operable—makes its own duct. Feature for feature, no other relay can match this new Square D control system.

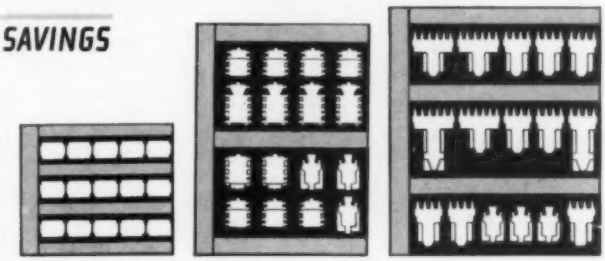

4-pole relay
8-pole relay
4-pole relay with timer attachment. Timer easily changed from on-delay to off-delay, is adjustable from 0.2 second to 1 minute
4-pole relay with memory latch attachment. Like timer, memory latch requires no additional panel space
Duct cover with supporting nylon post

SQUARE D COMPANY

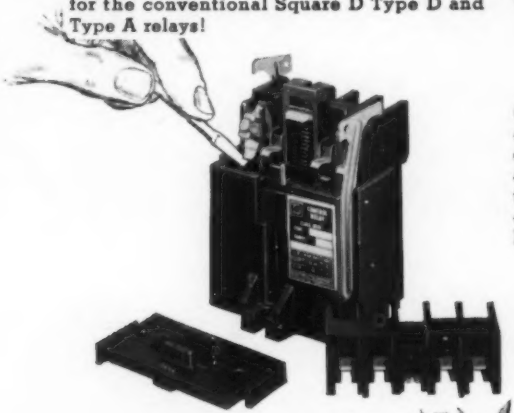
Drastically Reduced Panel Space!

NEW DESIGN MEANS BIG SPACE SAVINGS

Relays can butt together, save panel space through both small size and reduced wiring area. Each of these three panels provides 11 relay functions, 3 timing functions and 2 memory functions. Each is built with proper spacing for devices and wiring. Yet compare the size of the panel built with new Type G systems relays with the panel space required for the conventional Square D Type D and Type A relays!



Type G relays | Type D relays | Type A relays



Convert contacts from normally open to normally closed (or vice versa) without removing a screw, without adding a single part, without touching the stationary contacts or removing any wiring. Just flip over the movable contact with a screwdriver. All contacts double-break, individually convertible for any combination you need.

Easy-to-wire terminals are out in the open, even with the duct cover installed. Coil terminals are on the same level for quick accessibility. Pressure wire connectors are standard, with slip-on connectors also available.

Fast disassembly—Just lift up and slide back the latches and disassemble in seconds for quick coil change, contact conversion or inspection. No screws to remove, no special tools needed. Wiring stays undisturbed throughout.

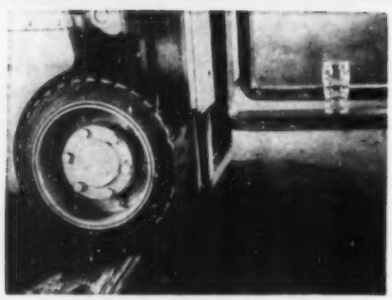
Manually operable and also gives visual indication of operation

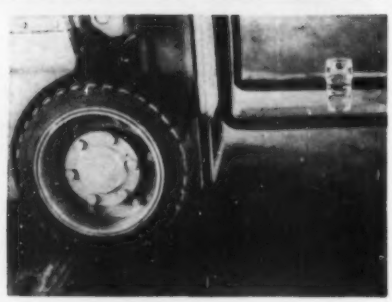
Get All the Facts! ***Send for Bulletin SM-307 with dimensions, ordering information—the complete story on the new Square D 300-volt control system. Square D Company, Dept. SA, 4041 North Richards Street, Milwaukee 12, Wisconsin.***

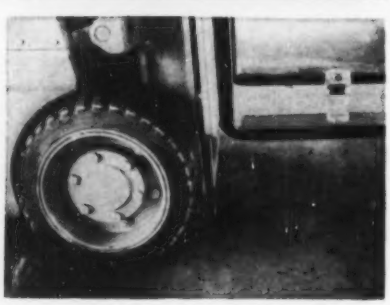
wherever electricity is distributed and controlled

Now Available in Production Quantities . . .
NEW HYDROSTATIC TRANSMISSION SYSTEM
THAT OUTPERFORMS ALL OTHER TYPES

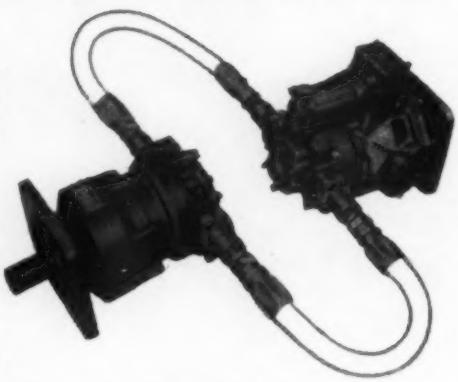
With throttle set at idle, a DYNAPOWER-ed Lift Truck eases up, over and down obstacle without disturbing water in glass . . . will move as easily up and down grades; on ice and snow; over sand, gravel and mud.







DYNAPOWER®
PAYS OFF IN
PERFORMANCE



DYNAPOWER uses a separate axial piston hydraulic pump and motor that produces torque as required up to 300 lb. ft. The variable pump provides an infinitely variable speed ratio and displaces a maximum of 4.8 cu. in./rev. The transmission is rated at a normal 60 HP but handles peak requirements up to 90.

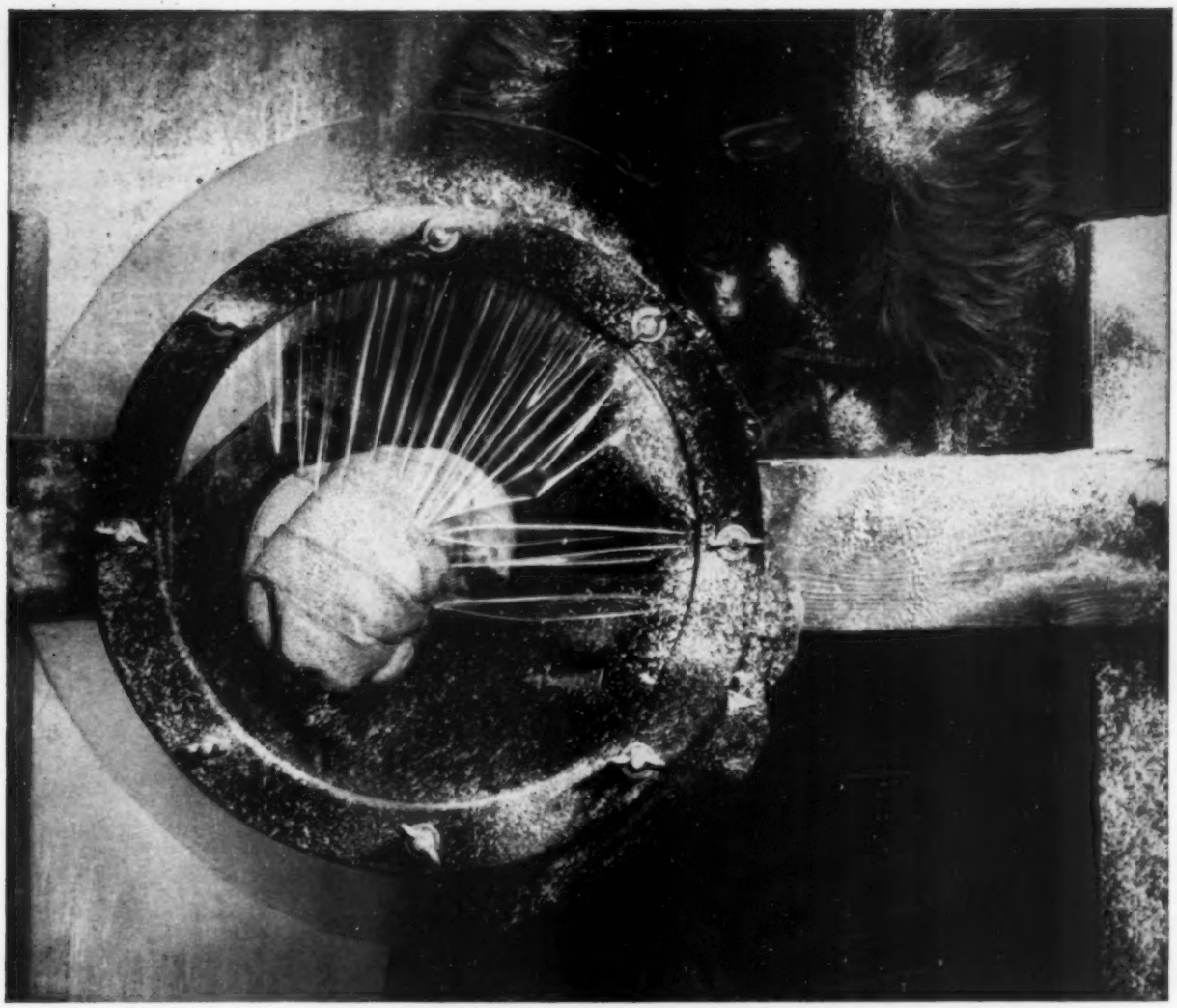
As a result, DYNAPOWER-ed off-road vehicles are able to deliver high torque at low RPM. Provide infinitely variable speeds in *either* direction without clutches or gear changers. Give faster smoother response. Reduce use of service brakes with Power Absorption Braking. And, simplify maintenance due to elimination of the drive train.

Application possibilities are endless. DYNAPOWER increases the power capabilities of LIFT TRUCKS without increasing size. DYNAPOWER increases useable HP output of FARM EQUIPMENT without prohibitive increase in cost. DYNAPOWER improves the vehicle geometry of MOBILE CONCRETE MIXERS and increases their capacity. DYNAPOWER reduces the high heat generation of constant volume open center type systems in SCRAPERS AND FRONTEND LOADERS.

DYNAPOWER has set new standards of performance and any off-road vehicle that cannot meet these standards will suffer in the buyers' market of 1962. Be sure you know all there is to know about DYNAPOWER, today! Write:

WATERTOWN DIVISION
THE NEW YORK AIR BRAKE COMPANY

1111 STARBUCK AVENUE • WATERTOWN, N. Y.



MYLAR® retains its high strength at -60°C.

Can the unique combination of properties found in "Mylar" help you solve your design problems?

Weatherable "Mylar" Type W resists ultraviolet light. This new film, with all the outstanding properties of regular "Mylar", will withstand long exposure to the sun's ultraviolet light. The film offers new design opportunities for outdoor applications.

"Mylar"* polyester film is a tough, flexible engineering material. In addition to its resistance to temperature extremes (-60° to 150°C.), "Mylar" has an average tensile strength of 20,000 psi, a dielectric strength of 4,000 volts per mil for 1 mil film, plus excellent resistance to most chemicals and moisture.

On an area basis, tough, thin "Mylar" often *costs less* than heavier, conventional materials. "Mylar" can be laminated, embossed and metalized, punched or coated. The film won't embrittle with age. "Mylar" is available in roll or sheet form in a wide range of gauges.

Find out how the *combination of properties* in "Mylar" can help you solve knotty design problems, improve product performance or cut cost. Write today for our new booklet containing detailed information on properties and applications. E. I. du Pont de Nemours & Co. (Inc.), Film Department, Room P-9, Wilmington 98, Delaware.

*"Mylar" is Du Pont's registered trademark for its brand of polyester film.

DU PONT
REG. U.S. PAT. OFF.
BETTER THINGS FOR BETTER LIVING
...THROUGH CHEMISTRY

DU PONT MYLAR® POLYESTER FILM

CIRCLE 51 ON READER SERVICE CARD 51

Which of these parts should be investment cast?

. . . *All* the parts except the milling machine collet at the top right—which is a "natural" for conventional lathe work. Even the helical impeller the men are examining is best made as an investment casting—the helix is undercut in such a way that no cutting tool could reach inside to remove the metal.

"Naturals" for investment casting are usually parts that are too intricate to be made economically by any other process, or involve alloys or quantities that make them impractical to produce by other methods. In other words, when it looks as if you might have to sacrifice a design because its complexity makes the cost prohibitive, or forego a preferred alloy because it is difficult to machine, then it's time to take a long, hard look at investment casting.

But . . . it's not always as easy as it sounds to spot the parts that are "made" for investment casting. That's where the Arwood sales engineer comes in. He knows Arwood expects him to show a customer how to get the most from the process. To help keep your cost down he may have to suggest a filleted radius here . . . or a tolerance opened up there. Then too, on occasion he may readily have to admit the part should not be investment cast at all. However, he also knows that if you just can't have the part made any other way, Arwood will go all the way down the line to have it investment cast for you.

Our five plants cast every castable metal and alloy, including magnesium and superalloys. Each has its own research, tooling, quality control and production facilities. In short, if it can be investment cast, we can investment cast it.

LIKE TO LEARN MORE ABOUT INVESTMENT CASTING?

Write us for a complimentary copy of our 44-page manual, "Practical Guide to Investment Casting." Among other sections it includes practical tips on designing for investment casting, as well as analyses and physical and mechanical properties of all the metals and alloys cast by Arwood.

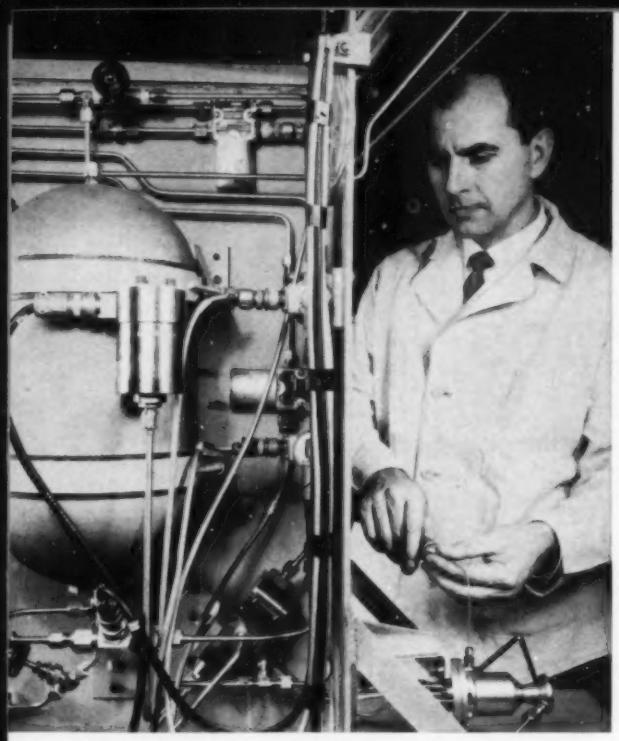
Machine the simple . . . cast the complex

A complete service from design through tooling, production and finish machining. Seventy-one engineering representatives from coast to coast.

arwood

ARWOOD CORPORATION • **325 West 44th Street, New York 36, New York**

PLANTS IN BROOKLYN, N. Y.; TILTON, N. H.; GROTON, CONN.; LOS ANGELES AND LA VERNE, CALIF.



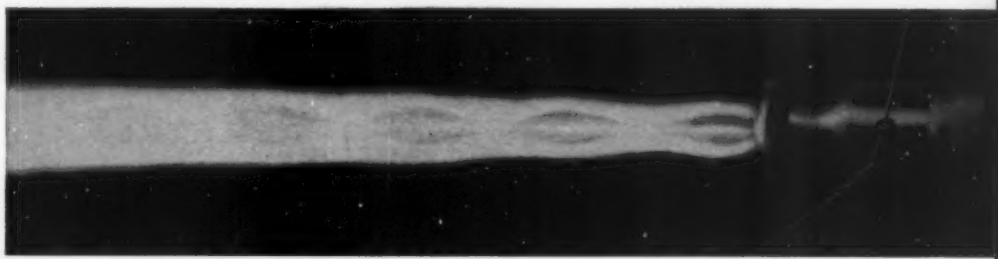
Special test facilities developed by Vickers Research and Development teams are used to evaluate nozzle designs, fuels, controls, instrumentation, etc. This setup is used in hypergolic bipropellant studies.

CAPABILITY
is spelled
a-t-t-i-t-u-d-e
c-o-n-t-r-o-l

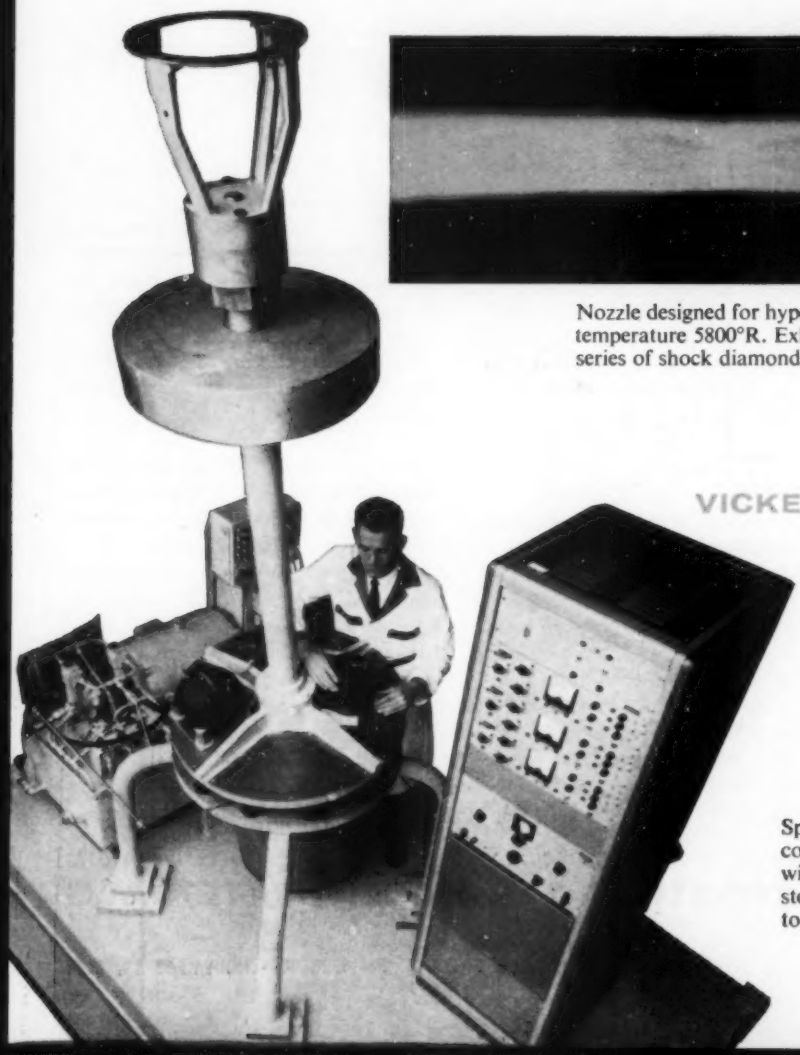
Selection of the optimum attitude control system for a particular missile or space vehicle requires special technical skills, facilities for conducting the necessary test program, and knowledge solidly based on related experience. All these are available "in quantity" at Vickers.

Actual experience dates back to hot gas servo studies initiated in 1955 and now covers the additional areas of hydrogen peroxide-powered reaction control, hypergolic bipropellants and secondary injection systems using either liquid (freon), or hot gas bled from engine combustion chambers.

The facilities and skills responsible for these developments in attitude controls are available to you as a vital aid in solving the problems of space-flight orientation. For more details, write for Bulletin A-5264, and/or call the Vickers' Application Engineer in your area. He is a thoroughly experienced practitioner in the "Programed Power"* field.



Nozzle designed for hypergolic bipropellant shown under test, flame temperature 5800°R. Exhaust flame is characterized by well defined series of shock diamonds.



AERO HYDRAULICS DIVISION
VICKERS INCORPORATED
DETROIT 32, MICHIGAN
TORRANCE, CALIFORNIA

division of
SPERRY RAND
CORPORATION

*PROGRAMED POWER IN:

POWER TRANSMISSION
ENERGY CONVERSION
FLUID TRANSFER

Space vehicle simulator used in development of attitude control systems weighs 2 tons, yet can be set in motion with a finger touch. Entire unit is supported on a 3-inch steel ball that floats on a hydrostatic bearing and is free to move in three planes: pitch, yaw and roll.

9781

Gasket engineering

TORQUE SEQUENCE vs. BOLT LOADS

Studies with new washer-type force gauges show how distribution of total bolt load on flanges is affected by torquing sequence, and how distribution varies with the amount of the load.

E. M. SMOLEY, Research Physicist, Armstrong Research and Development Center

To insure a seal on a gasketed joint, it is important not only that flange pressures be adequate but that these pressures be distributed as uniformly as possible around the flange.

One of the factors affecting distribution of flange loads is the sequence in which bolts are torqued. This problem was recently studied by engineers at the Armstrong Research and Development Center.

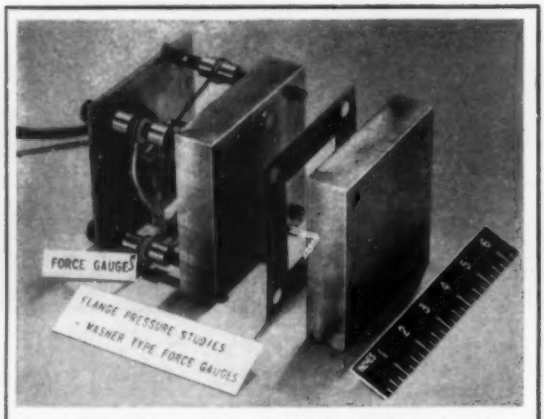


Figure 1. Breakdown photo of test flange shows how force washers were used to measure distribution of bolt loads. Gauges are between load sleeves.

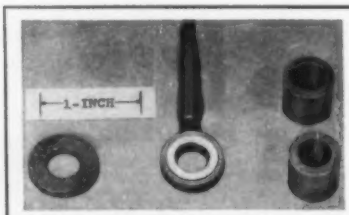


Figure 2. Washer-type force gauge compared with standard flat washer. Load sleeves at right are used to equalize load. Force gauges supplied by Lockheed Electronics Co., Avionics and Industrial Products Division, 6201 E. Randolph St., Los Angeles, Calif.

The engineers used a test flange which was fitted with a new type of strain gauge called a force washer. (See Figures 1 and 2 and captions) These gauges, no larger than an ordinary washer, were placed on each bolt and wired individually to a recorder that charted the actual loads.

Separate tests were then run, with each bolt tightened to torque wrench readings of 5, 10, 15, 20, and 25 pound-feet. The bolts were tightened as shown in Figure 3.

On the basis of the original torque wrench readings, it would be assumed that the load on each bolt, and the distribution of the total load, would be about equal. Each bolt would then bear about 25% of the total load.

Our tests indicate that this is not true. Actually, the act of tightening one bolt can raise or lower the loading on bolts already torqued.

This is demonstrated by the plot of the force gauge readings in Figure 3. For example, with all bolts torqued to five pound-feet, our force gauges indicate that, in terms of total load, 15% is on bolt #1; 5% on #2; 45% on #3; and 35% on #4.

As the initial torque level is increased, the distribution of the load becomes more equal and each bolt carries more of its planned share. At 25 pound-feet, each bolt is carrying about 25% of the load.

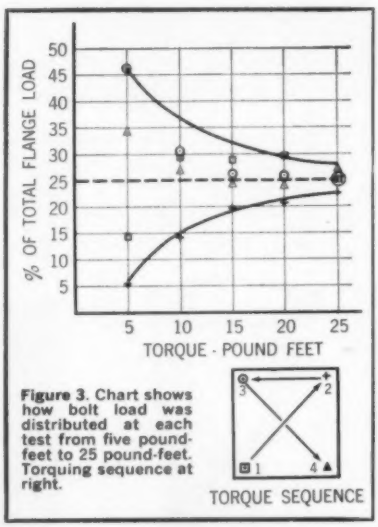


Figure 3. Chart shows how bolt load was distributed at each test from five pound-feet to 25 pound-feet. Torquing sequence at right.

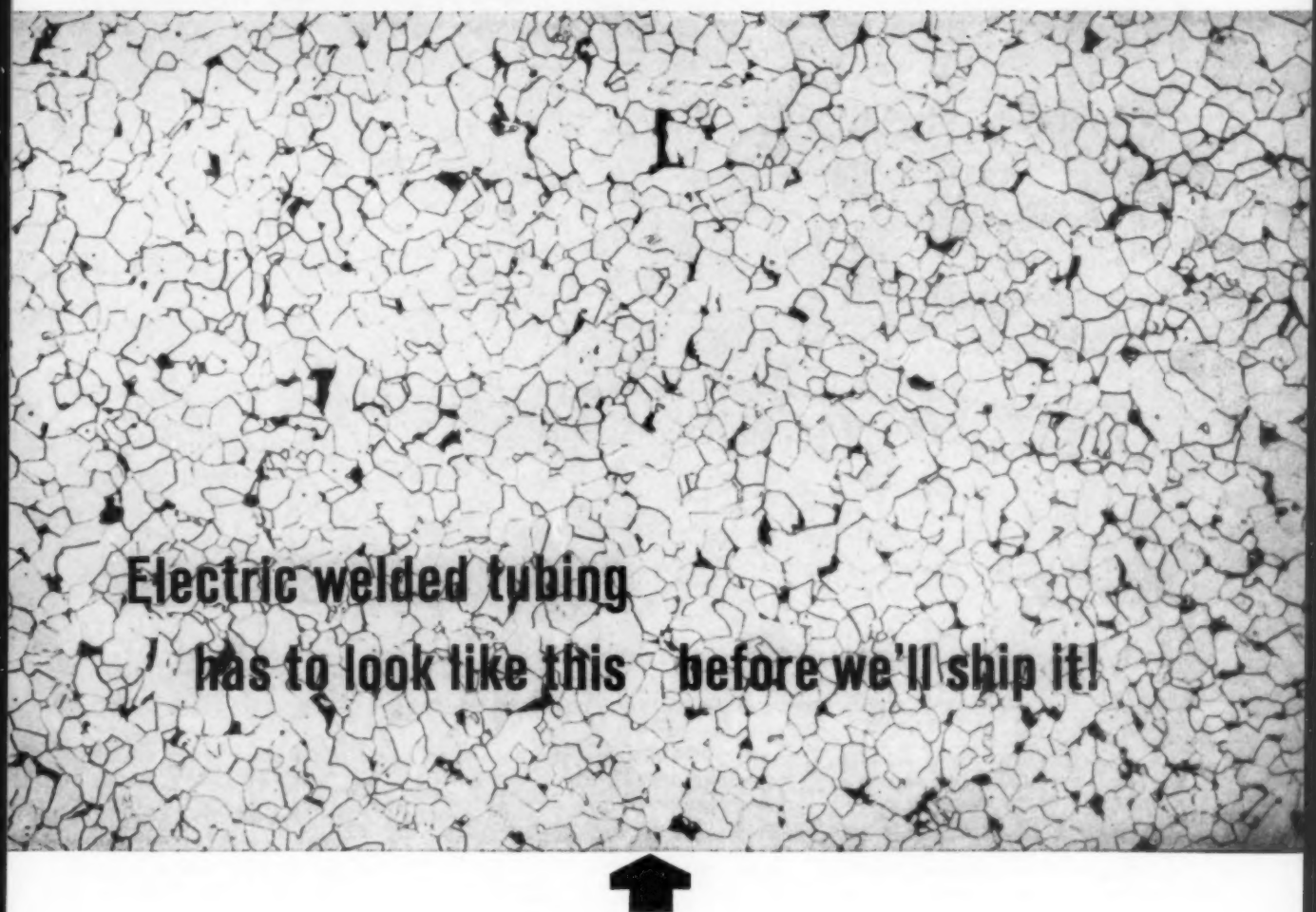
This data confirms previous findings which indicate that the best seals are obtained by using the maximum torque obtainable with a specific flange design. It also has broad practical application in the many instances where bolt torques of 15 pound-feet or less are used.

Studies on the effect of torquing sequence are part of our continuous engineering research on gasket performance. Our large library of data may already contain the answers to your specific sealing problem. We will be glad to make suggestions if you will submit details to us. Write Armstrong Cork Company, 7111 Irvin Street, Lancaster, Pennsylvania.

Armstrong GASKET MATERIALS

This mark tells you a product is made of modern, dependable Steel.

Portrait of a perfect weld Magnification—100X; Etch-Picral Nital



In this photomicrograph of a section of USS National Electric Resistance Welded Steel Mechanical Tubing the weld section runs right down through the center of the picture above the arrow. The consistency of structure between the weld area and the rest of the tube shows that USS National Welded Mechanical Tubing has an important attribute—dependability.

Mechanical tubing must be flawless. It's used in so many critical applications that demand utmost strength, excellent surface inside or outside and extreme dimensional accuracy. National Tube's production methods assure this high quality.

Important advantages of USS National Welded Mechanical Tubing are its ability to reduce machining operations to a minimum or eliminate them entirely. For a given weight, it withstands more load than any other section. It resists bending stresses equally in all directions. In torsion, it provides maximum material distribution.

USS National Welded Mechanical Tubing is available in cold-drawn or hot-rolled sizes ⅜″ thru 5½″ and in wall thickness .035″ to .250″. All sizes can be obtained from National Tube Distributors located throughout the country. They will gladly show how tubing can reduce your costs. *See your USS National Tube Distributor.* *USS and National are registered trademarks*

National Tube Division of United States Steel

Columbia-Geneva Steel Division, San Francisco, Pacific Coast Distributors • United States Steel Supply Division • United States Steel Export Company, New York

CIRCLE 55 ON READER SERVICE CARD

Designers think of R/M first for asbestos, rubber,

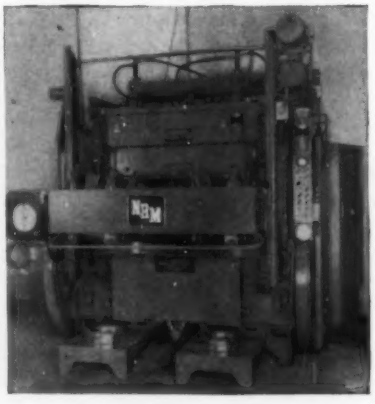
Solves major operating problems for tire press manufacturer with new Teflon*-impregnated molded asbestos piston cups

New molded asbestos piston cups impregnated with Teflon, developed by Raybestos-Manhattan, Inc., have enabled National Rubber Machinery Company, Akron, Ohio, to improve the economy and efficiency of its Autoform Slideback Tire Press while realizing substantial savings. The new seal has not only reduced air loss to a minimum, but eliminated a lubrication system, cut maintenance, and increased machine operating life.

Before adopting R/M cups, NRM used metal rings for the ram and cylinder assembly. These did not provide the seal required, permitted a 5 to 10% air loss, caused excessive wear on moving parts, and required lubricants which were entrained, seeped into the molds, and damaged the tire rubber.

In considering a suitable replacement for the metal rings, NRM tested various synthetic rubber and leather cups. All deteriorated rapidly in temperatures up to 380°F. Then R/M was consulted. Preliminary investigation indicated asbestos with a Teflon filler as a potentially good combination for this application. Nearly a year of research, testing and engineering collaboration followed. Samples were developed and tested in the field under actual operating conditions. Only when all results were in—after two years—did NRM adopt R/M cups for use in all its presses.

R/M's experience in the manufacture of packings, gasket materials, and specialty products to meet the exacting and varied requirements of industry is at your disposal—whatever your need call on R/M.



The application of R/M piston cups provided two important benefits. It eliminated oil in the curing room, preventing damage to the tire rubber. It reduced air loss with properly fitted and installed cups.

Registered trademark for Du Pont fluorocarbon resins

PACKINGS

For complete information on R/M Molded Piston Cups and other R/M packings and gasket materials, write for new Catalog P-100. Packing Division, Raybestos-Manhattan, Inc., Passaic, N.J.

sintered metal, and engineered plastic products

Non-burst Rubber Steam Hose

Strength of steel, heat resistance of asbestos, flexibility of rubber

For saturated steam pressures to 200 lbs., 388°F. Strength and durability are employed throughout the construction of Super-Master BW Steam Hose, illustrated above. Braids of high-tensile, non-corrosive steel wire are applied at a controlled angle over an asbestos-covered steam-resistant rubber tube for greatest strength with minimum elongation and contraction, and provide positive protection against bursting. Special Butyl rubber cover resists heat and weather, has static dissipating wire. The safest high-pressure steam hose made. Write for Bulletin M630.

Rubber hose for every purpose—air, oil, suction, Teflon hose for corrosive chemicals, flexible rubber pipe and expansion joints for abrasion and vibration . . . outlasts steel pipe. Write for Catalog M5.

BOND FAILURES CAN BE PREVENTED!

Here's how to stop 13 of them . . .

Type of Failure	Solution
THERMOSETTING ADHESIVES	
• Cohesive failure	Check film with solvent used in adhesive. If solvent softens the adhesive film or becomes tacky, this indicates insufficient cure. Make sure bond line time and temperature is used.
• Adhesive failure from metal	If metal surface has a white, clean appearance, check cleaning technique.
• Adhesive failure from substrate other than metal	Try prime coat of diluted adhesive, also check compatibility.
• Cellular areas in adhesive line	Increase pressure and/or adhesive.
CONTACT ADHESIVES —room temperature setting	
• Tacky film	If film should dry hard but remains tacky, the cause may be entrapped solvent or migration of plasticizer from one substrate.
• Shiny areas	Poor contact, insufficient pressure or insufficient amount of cement.
• No bond	If heat reactivated type, adhesive was too cool at time of assembly or poor compatibility.
• Failure in adhesive from metal	Improper cleaning.
• From substrate other than metal	Incompatible or unclean surfaces.
HOT MELT	
• No bond	Incompatibility, adhesive too cool at time of assembly. Parts too cool at time of application of adhesive.
EPOXY BASE ADHESIVES AND CASTING COMPOUNDS	
• High exotherm	Mix lower volume and pour mixed material into shallow tray. Cool base and activator before mixing or use Metermixing equipment.
• Tacky film or casting	Improper base activator ratio, improper mixing of base and activator, improper cure. Check bond line temperature.
• Flexible casting or film of rigid adhesive or casting compound	Improper mixing of base and activator, improper base and activator, improper cure. Check bond line temperature.

Bond failures can be prevented! Raybestos-Manhattan's adhesive experts also have solutions to less common causes of bond failures . . . based on more than 20 years' experience in the production of bonded assemblies and the manufacture of adhesives, coatings and sealers. Why not call on them today for the answers to your adhesive problems—no cost or obligation, naturally.

RUBBER

Write today for free booklet shown: full details on a wide variety of industrial rubber products. Manhattan Rubber Division, Raybestos-Manhattan, Inc., Passaic, N. J.

ADHESIVES

Get helpful engineering information on selecting, bonding and testing adhesives. Write today for your free copy of Bulletin No. 701. Adhesives Department, Raybestos-Manhattan, Inc., Bridgeport, Conn.

RAYBESTOS-MANHATTAN, INC.

FACTORIES: Passaic, N.J. • Bridgeport, Conn. • Manheim, Pa. • Paramount, Calif. • No. Charleston, S.C.
Crawfordsville, Ind. • Neenah, Wis. • Peterborough, Ontario, Canada

GRAPHITAR®

(CARBON-GRAPHITE)

FOR DEPENDABILITY

GRAPHITAR'S own character makes it dependable. A non-metallic engineering material, formed from carbon and graphite powders and a special binder, compacted under high pressures and furnaced at temperatures up to 4,500°F., GRAPHITAR possesses inherent characteristics that give finished parts exceptional dependability. GRAPHITAR'S natural heat resistance, for example, gives bearings, seals, vanes and rings exceptional dependability whenever dependability is one of the prime requisites.

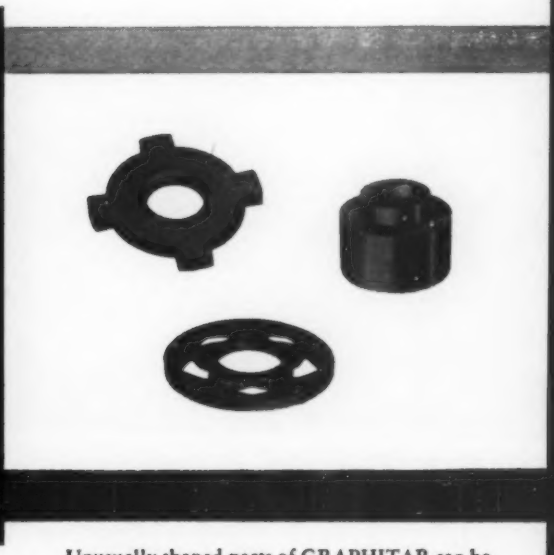
There are other characteristics every bit as important to GRAPHITAR'S dependability. They include chemical and magnetic inertness, mechanical strength and adaptability to self-lubrication. Besides these natural characteristics, GRAPHITAR engineers can control porosity, strength and hardness to match GRAPHITAR'S physical properties to each individual application. It's little wonder that GRAPHITAR has become one of the design engineer's most versatile and useful materials.

In this laboratory test stand, oxidation-resistant GRAPHITAR parts are being checked under simulated operating conditions. Similar tests have proven that, when GRAPHITAR parts are exposed in oxidizing atmospheres at 1,200°F., they show only a weight loss of less than six percent after 200 hours.

With the aid of photomicrographs, engineers at The United States Graphite Company gain valuable information about the microstructure of GRAPHITAR parts. Modern laboratory equipment such as the Metallograph enables engineering personnel to advance product quality for maximum dependability. Extensive and continuing R&D work has always been an integral part of The United States Graphite Company's operations.

GRAPHITAR air/oil seals employed in today's high-speed turbojet engines have established an enviable record for operating dependability. Installed on the main shaft of the turbine, GRAPHITAR seals successfully withstand tremendous shaft speeds and generated heat.

GRAPHITAR bearings in the power reactor pumps of American nuclear submarines have compiled an outstanding record for dependability.



Unusually shaped parts of GRAPHITAR can be molded easily with today's modern techniques. Ears, face slots and outside diameter notches of friction disc above, left, were molded in one operation without need for secondary machining and finishing.

Do you have an application in which GRAPHITAR'S dependability can help solve a tough problem, reduce your costs and improve the operational life of your products? Our engineering staff can help you find out. Our field men can also give specialized, on-the-job consultation. Send for your free copy of Engineering Bulletin #20. Included is helpful information about the properties, characteristics and applications of GRAPHITAR.

THE UNITED STATES GRAPHITE COMPANY

DIVISION OF THE WICKES CORPORATION, SAGINAW 1, MICHIGAN

GRAPHITAR® CARBON-GRAPHITE • GRAMIX® POWDER METALLURGY • MEXICAN® GRAPHITE PRODUCTS • USG® BRUSHES

P-294-2R

CIRCLE 59 ON READER SERVICE CARD

WHY PAY FOR METAL WASTE?

Here is how to cut costs on your next tube order . . . by eliminating excessive metal waste and unnecessary machining time.

NOW FOR THE FIRST TIME you can order the exact size tube O.D.'s you need from 2.25" to 50" with wall thicknesses from .25" to 8". An exclusive "first" in centrifugally spun tubing — the ACIPCO CERAM-SPUN® process* makes this revolutionary development possible.

YOU BUY WHAT YOU NEED . . . NO MORE. Furthermore, the cost of unwanted crop ends can be eliminated and tubes can be cast to specified lengths from 4 feet to 20 feet. Longer lengths are made by welding.

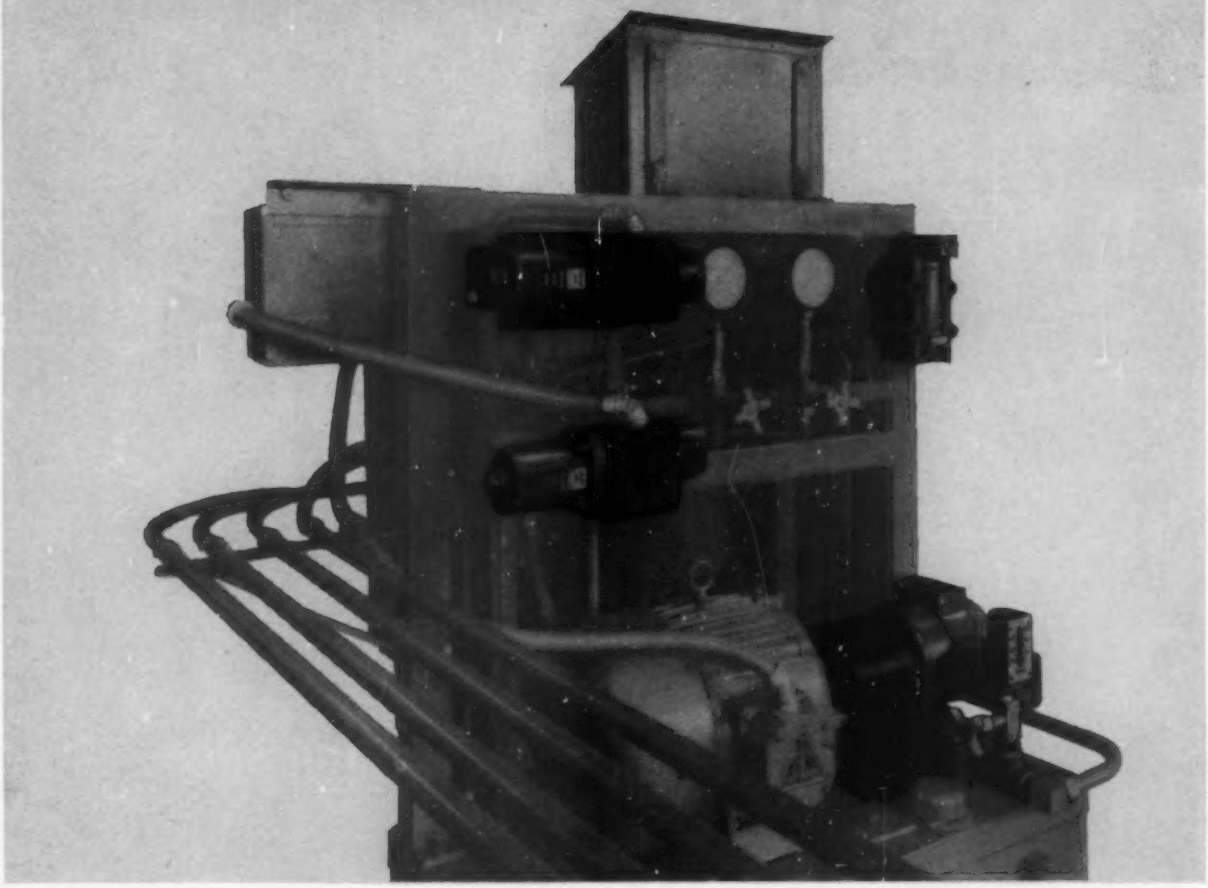
OTHER ADVANTAGES? ACIPCO's complete "under one roof" operations — including heat treating, machining and welding — save you the delays and excessive costs that often result in buying from multiple supply sources.

Let us tell you more about ACIPCO CERAM-SPUN® . . . contact us today. ACIPCO STEEL PRODUCTS, Division of American Cast Iron Pipe Company, Birmingham 2, Alabama.

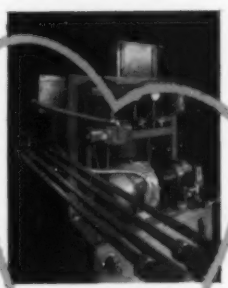
*Patent applied for

ACIPCO CERAM-SPUN®
STEEL TUBING

Is hydraulic vibration one of your design problems?



Scans Associates solved this problem with a Racine Hydraulic System



Porosity testing machines manufactured for major Detroit transmission plant by Scans Associates, Livonia, Michigan.

"It would take an Act of Congress to make us use any equipment except Racine components for our porosity testing machines," says Mr. Vernon G. Converse, President of Scans Associates, Livonia, Michigan. The machine — which makes 4 different leakage tests on transmission cases in a 20-second cycle — must check porosity to ¼ inch of water pressure. The machine hydraulically clamps the part firmly in place and tightly plugs all openings. Air pressure and vacuum are alternately applied inside the part, and changes in pressure are pneumatically measured. The slightest hydraulic vibration would distort the readings. "This demands hydraulic equipment that is both extremely sensitive and steady," states Mr. Converse. "Racine has always met both requirements perfectly." The Racine system in this application consists of a Model S variable volume pump, a self-contained 30-gallon reservoir, a 5HP motor and 3 Racine valves (one of them for pressure reduction).

If your application demands sensitivity and precision in hydraulic control, a compact Racine system can meet your requirements.

RACINE HYDRAULICS & MACHINERY, INC. RACINE, WISCONSIN

We're interested in knowing more about Racine Hydraulic Systems. The application of interest to us is _____

NAME _____ TITLE _____

FIRM _____

ADDRESS _____

CITY & ZONE _____ STATE _____

RACINE

RACINE designs systems to solve hydraulic problems

←CIRCLE 60 ON READER SERVICE CARD

CIRCLE 61 ON READER SERVICE CARD 61

Madison-Kipp zinc and aluminum die castings

These five castings assembled in the order that you see them are engineered for a radial arm saw. Intricate in design, they must match perfectly and that means extremely close tolerances. Mass production demands a minimum of secondary operations.

This is just one example of the wide range of castings that Madison-Kipp is called upon to engineer and produce—in quantity. All, however, have one thing in common—the need of a dependable source with years of seasoned experience in producing die castings.

We have a 24-page book showing some of the die casting problems we have solved, and containing information on other Madison-Kipp products. A copy is yours for the asking. Write for one.

kipp

MADISON-KIPP CORPORATION

206 Waubesa Street • Madison 10, Wisconsin, U.S.A.

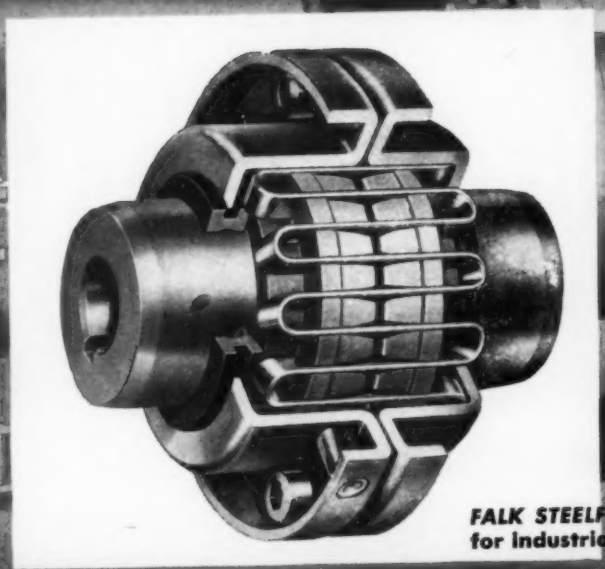
Skilled in Die Casting Mechanics • Experienced in Lubrication Engineering • Originators of Really High-Speed Air Tools

62 CIRCLE 62 ON READER SERVICE CARD

CIRCLE 63 ON READER SERVICE CARD→

FALK

A GOOD NAME IN INDUSTRY



FALK STEELFLEX COUPLINGS
for industrial applications...large or small

Giant Falk Coupling smooths out steel blooming mill performance

On a blooming mill at the Copperweld Steel Company plant in Warren, Ohio, installation of a large Falk Steelflex coupling between motor and pinion stand eliminated troublesome noise and vibration which threatened to damage mill machinery. Transmitting 5,000 hp at 50/100 rpm, this is not the largest Falk coupling... others are designed to transmit up to 130,000 hp at 100 rpm.

This installation and others like it prove the Falk concept of shaft coupling design—namely, a modern shaft coupling must contribute to the successful performance of the machinery system.

What does this mean to you? Just this: On large machines as well as small, the exclusive Falk grid-groove design does make a difference, and the difference is torsional resiliency with the strength of steel...reason enough to specify Falk Steelflex couplings as "long life" insurance for your connected machinery.

Falk Steelflex couplings are available in standard designs in 34 sizes for applications from .3 hp at 100 rpm to 130,000 hp at 100 rpm, with excellent delivery. Write for Bulletin 4100.

THE FALK CORPORATION, MILWAUKEE 1, WISCONSIN

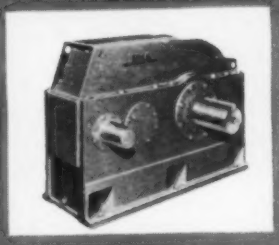
MANUFACTURERS OF QUALITY GEAR DRIVES AND FLEXIBLE SHAFT COUPLINGS

Representatives and Distributors in most principal cities

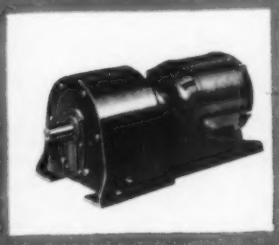
• • •

A Point to Ponder...When you need gear drives or shaft couplings of "FALK OR EQUAL" quality, where but from Falk can you get the "OR EQUAL"?

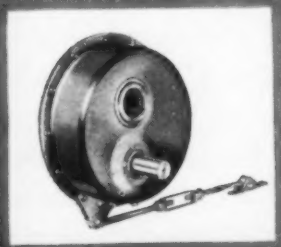
Other members of America's First Family of Power Transmission Products



SPEED REDUCERS
Parallel Shaft up to 3500 hp. Ask for Bulletin 1100. Also Right Angle and Concentric Shaft designs.



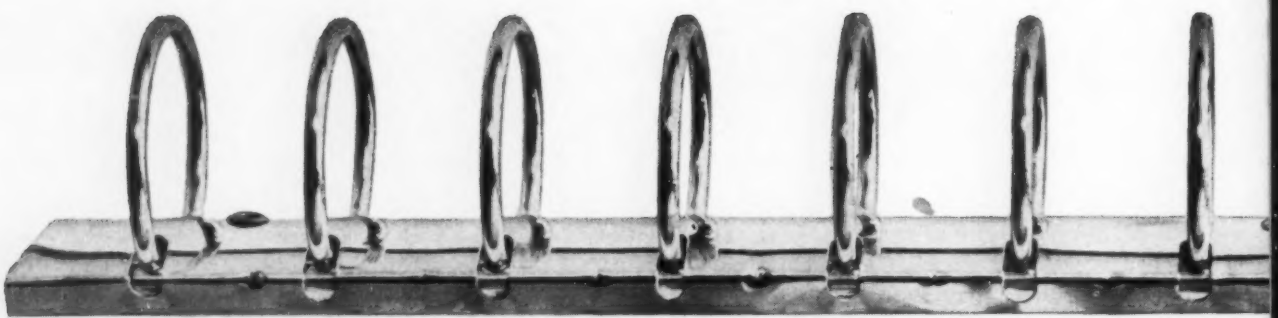
ALL-STEEL MOTOREDUCERS
—up to 75 hp. Horizontal, Vertical, and Right Angle. All-Motor and Integral Types. Ask for Bulletin 3100.



SHAFT MOUNTED DRIVES
—up to 125 hp. Ask for Bulletin 7100. Also Flange Mounted and Screw Conveyor Drives.

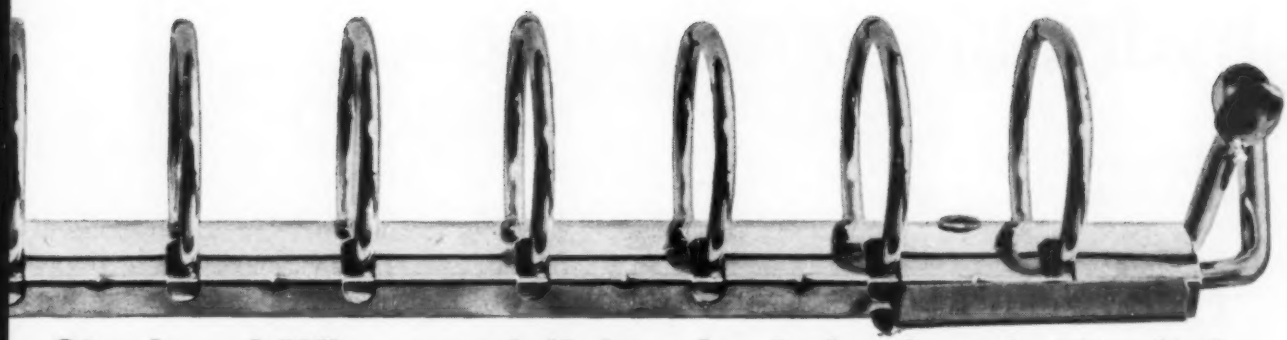
FALK, STEELFLEX and ALL-MOTOR are registered trademarks

This mark tells you a product is made of modern, dependable Steel.



This is a new kind of ring binder. Below: the American

It opens, closes, and locks the rings, preventing spilled sheets. That's about all a ring binder does. And yet, coming up with the right wire for this binder was more than half a job. National Blank Book Company, Holyoke, Mass., asked our sales representative for an assist. He conferred with Charlie Canney—one of our top service metallurgists. **1.** Charlie met the people at National. **2.** He talked to their production people, came up with a profile of the wire they wanted. It had to have a uniform temper, the right temper for making the binder's snap-action ears, a clean, smooth surface for welding and plating, a temper which would vee-notch cleanly and still be rigid enough to stand distortion during production. **3.** Charlie took his problem back to our Worcester plant, talked it out with Clyde Westhaver, general foreman of cleaning, coating, heat treating; and Fred Brierly, product metallurgist. **4.** And then to the Metallograph—an instrument used in one of the many tests that determine the right properties. **5.** Charlie's report followed. **6.** Next, into limited production on the wire.



Steel and Wire specialists who helped make it click.

Wilfred Blades, quality control supervisor, and Francis Whalen, works metallurgist, kept close check on its condition during the initial draw. **7.** Before shipment, Arthur Weissinger and John Conrad, lab technicians, took stress-strain recordings **8.** The result: a ring binder that works just fine, and another satisfied customer. Call your American Steel and Wire salesman or nearest sales office the next time *you* need a metallurgical assist, or the best wire you can buy. American Steel and Wire, Rockefeller Building, Cleveland 13, Ohio.

Innovators in Wire

USS TRADEMARK

American Steel and Wire Division of United States Steel

Performance, application and operating characteristics of new 2500 psi hydraulic vane pumps

By: Robert A. Manogue
Pumps/Controls Product Manager
Denison Engineering Division
American Brake Shoe Co.

In designing hydraulic circuits, it is normal to limit line velocities to a maximum of from 15 to 20 feet per second. This permits the use of the smallest practical lines, valves and fittings. Pressure drop in transmitting the fluid is thus dependent on flow velocity, number of valves and fittings and line length. For example, if the pressure drop of a given system is 50 psi, it represents a loss in transmission of 5% for a 1000 psi system and a loss of only 2% for a 2500 psi system. Power loss in transmission is reduced 60% by using 2500 psi components.

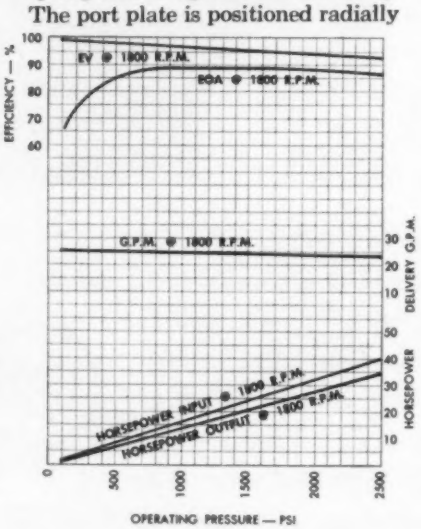
Net advantage is a more efficient hydraulic system with lighter weight and less cost-per-horsepower in smaller, more easily installed components than is possible with comparable lower pressure systems.

PERFORMANCE CHARACTERISTICS

Based on these inherent advantages for 2500 psi, Denison has engineered and produced a new series of "T1C" vane pumps with rated deliveries of 8, 11, 14 and 17 gpm at 1200 rpm and zero psi. Major considerations in designing the new pump were: Higher efficiency, speed and pressure for continuous duty to 2500 psi and 2500 rpm—as well as lower cost, ease of maintenance and compactness. The T1C pump shaft will support a radial load of 479 pounds at the center of the keyway.

PUMP CONSTRUCTION

The pump is a "cartridge" type design for quick, convenient servicing. It consists of a housing which provides an inlet connection, a bore for support of the shaft bearing and shaft assembly. The lip-type shaft seal is located outboard of the front bearing in the housing to permit bearing lubrication, using the fluid being pumped. A larger bore contains a floating front port plate, spring-loaded against the cam ring. The port plate is positioned radially by a dowel pin between the housing and port plate. The cam ring is located in a close-fitting bore and positioned radially by a dowel pin between the end cap and cam ring. Besides retaining the cam ring in the housing, the end cap contains suction and pressure cores and the outlet connection.



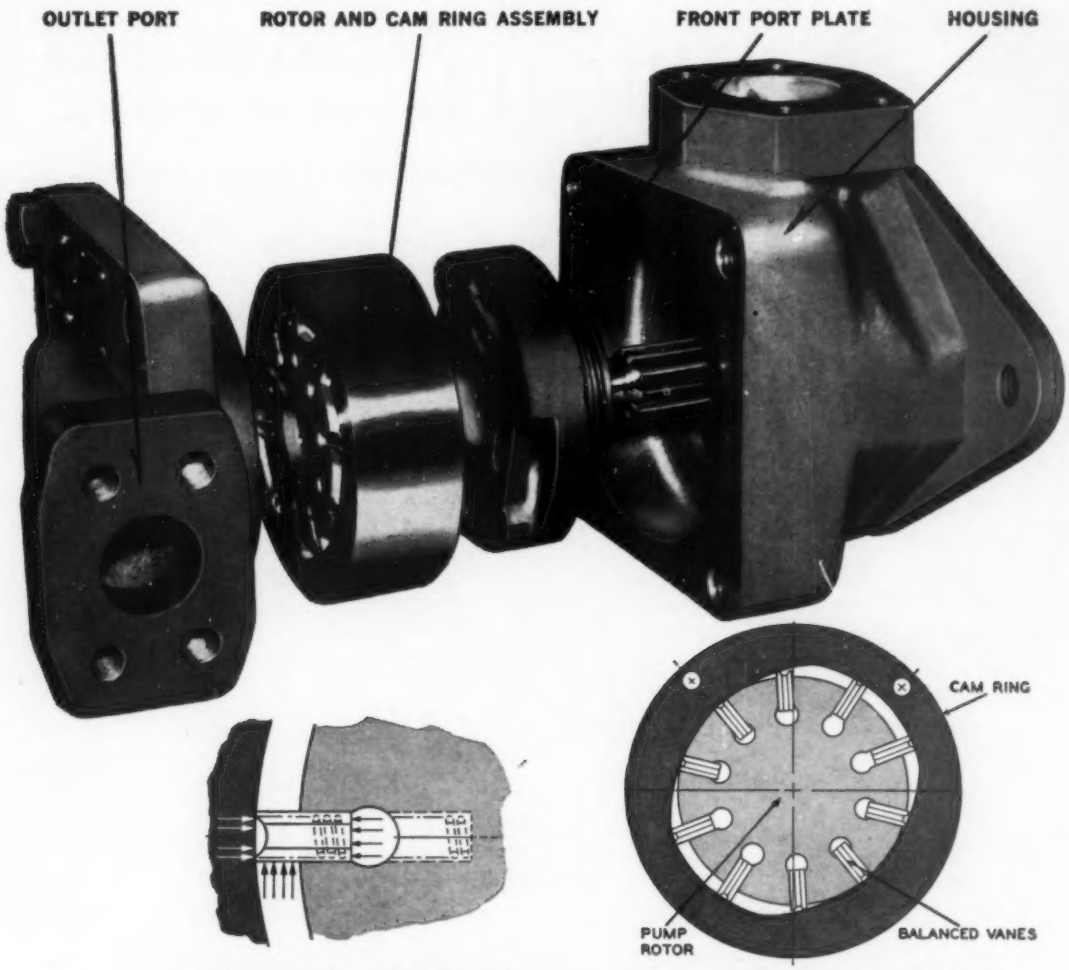
PERFORMANCE CURVES *demonstrate high volumetric efficiency of new 2500 psi Denison vane-type hydraulic pumps.*

To simplify piping, the end cap can be rotated to any one of four positions. The port pads on the pump match the four-bolt SAE port pads. An SAE "B" size mounting flange is provided on the standard pump. An alternate SAE splined shaft is available.

OPERATING CHARACTERISTICS

In operation, oil enters the pumping cavity through cast ports in the port plate and end cap. Oil is carried around to the discharge ports in the end cap and out the outlet port. The pump is internally drained at all times. The end cap contains a cored passage behind the bearing which allows a flow of oil through the bearing back to suction, keeping the bearing cool and minimizing wear.

A unique feature of the T1C pump is the floating front port plate which is free to move axially within limits. It utilizes hydraulic pressure to counteract internal hydraulic pressure that tends to separate the elements of the pumping cartridge after the pump is primed and delivering pressure to the circuit. A light spring



BALANCED OPEN-END VANE DESIGN *assures low wear through continuous pressure balancing which relieves hydraulic bearing loads between vanes and cam ring.*

ROTOR AND CAM RING ASSEMBLY *with large inlet ports for improved suction characteristics. Rotor is balanced axially and radially for consistently high volumetric efficiency and long life.*

is used to hold the pumping cartridge together when there is no pressure in the system and for starting. The floating plate construction minimizes scoring the wear faces on the front port plate and the end cap.

Oil flow in the pump is always from the inlet in the housing to the outlet in the end cap. Shaft rotation may be changed by simply repositioning the cam ring. Arrows indicate desired direction of rotation. The pump can be either flange or bracket mounted.

Other characteristics include: Oil, 150-300 SSU @ 100°F. Viscosity index, 90 or above. Minimum running viscosity, 65 SSU. Maximum viscosity at starting temperature, 7500 SSU. Data was determined with petroleum base oils.

APPLICATIONS

Among particularly suitable applications for new T1C pumps are: Mobile equipment—including earth-moving units, trucks, buses, tractors and power shovels where 2500 psi power can mean lower weight, increased payloads and greater user operating profit. Special machinery—including extrusion presses where the compact pump puts more power into less space. Automated production equipment—where feed circuits and index mechanisms benefit through the increased operating efficiency and low maintenance of 2500 psi hydraulics.

DESIGNERS and ENGINEERS

New 8-page Bulletin 200A includes specifications, performance and operating application data on new 2500 psi Denison balanced-vane hydraulic pumps. Write for your copy.

DENISON ENGINEERING DIVISION
American Brake Shoe Company
1194 Dublin Road • Columbus 16, Ohio

CIRCLE 67 ON READER SERVICE CARD 67

McGILL® prelubricated and sealed bearings

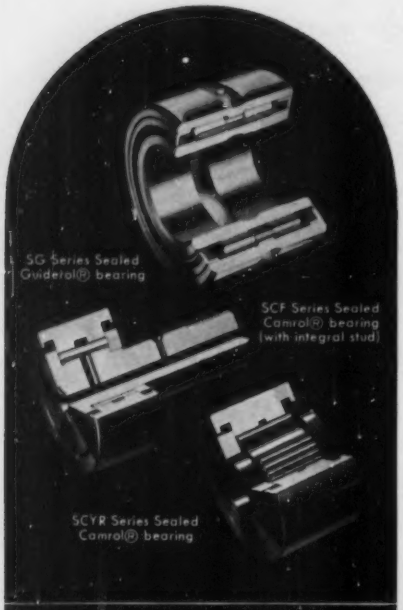
insure product performance

Contamination and loss of lubricant cut bearing life drastically. That's why more and more manufacturers are specifying McGill sealed bearings. Integral seals extend bearing life and keep equipment in service even under adverse field conditions.

You can expect full rated life from McGill sealed bearings in applications involving exposure to dirt and grit or contaminants which tend to dilute the lubricant. They're also ideal where re-lubrication is impractical or difficult.

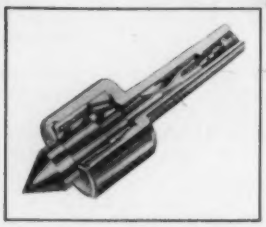
McGill sealed GUIDEROL and sealed CAMROL bearings eliminate the need for expensive auxiliary seals. Each bearing is complete and they are easy and economical to apply.

Sealed CAMROL bearings are available in roller diameters up to 4", with or without integral stud. Also available with extra heavy stud. Sealed GUIDEROL bearings are available in shaft sizes from $\frac{5}{8}$".


SG Series Sealed Guiderol® bearing
SCF Series Sealed Camrol® bearing (with integral stud)
SCYR Series Sealed Camrol® bearing

Seals keep lubrication in, abrasives out in SCF CAMROL lapping machine use

Sealed SCF Series CAMROL bearings position conditioning rings into which work pieces are placed in Crane Packing Company LAPMASTER lapping machines. The bearings roll in a loose abrasive and oil environment. The user reports longer life with less maintenance than the ball bearings formerly used.



"Live Center" application

Motor Tool Manufacturing Co. reports that the sealed GUIDEROL bearings used in their new heavy duty live centers will carry heavier radial loads for their diameters than any bearing they know of. They also state that performance difficulties run less than 1% in spite of severe operating conditions.

Sealed GUIDEROL and Sealed CAMROL bearings used by JOHN DEERE

McGill Sealed GUIDEROL bearings at each end of the connecting rods and at the end of the swing-arm sickle drive of John Deere No. 10 side-mounted mowers reduce friction and assure efficient field operation. The sealed GUIDEROL bearings in their exposed positions are indicated in the photo above at left. The swing-arm sickle drive bearing outlasts three bronze bushings in the application. Oscillating loads of approximately 700 pounds are encountered in this position. The connecting rod bearings are subjected to reciprocating loads of 1600 pounds.

Deere also uses sealed SCYR series CAMROL bearings in plunger head guider rollers in their 323-W balers.

CONSULT McGILL EARLY
IN YOUR PRODUCT R and D
specialized engineering saves time, improves design

engineered electrical products

McGILL®

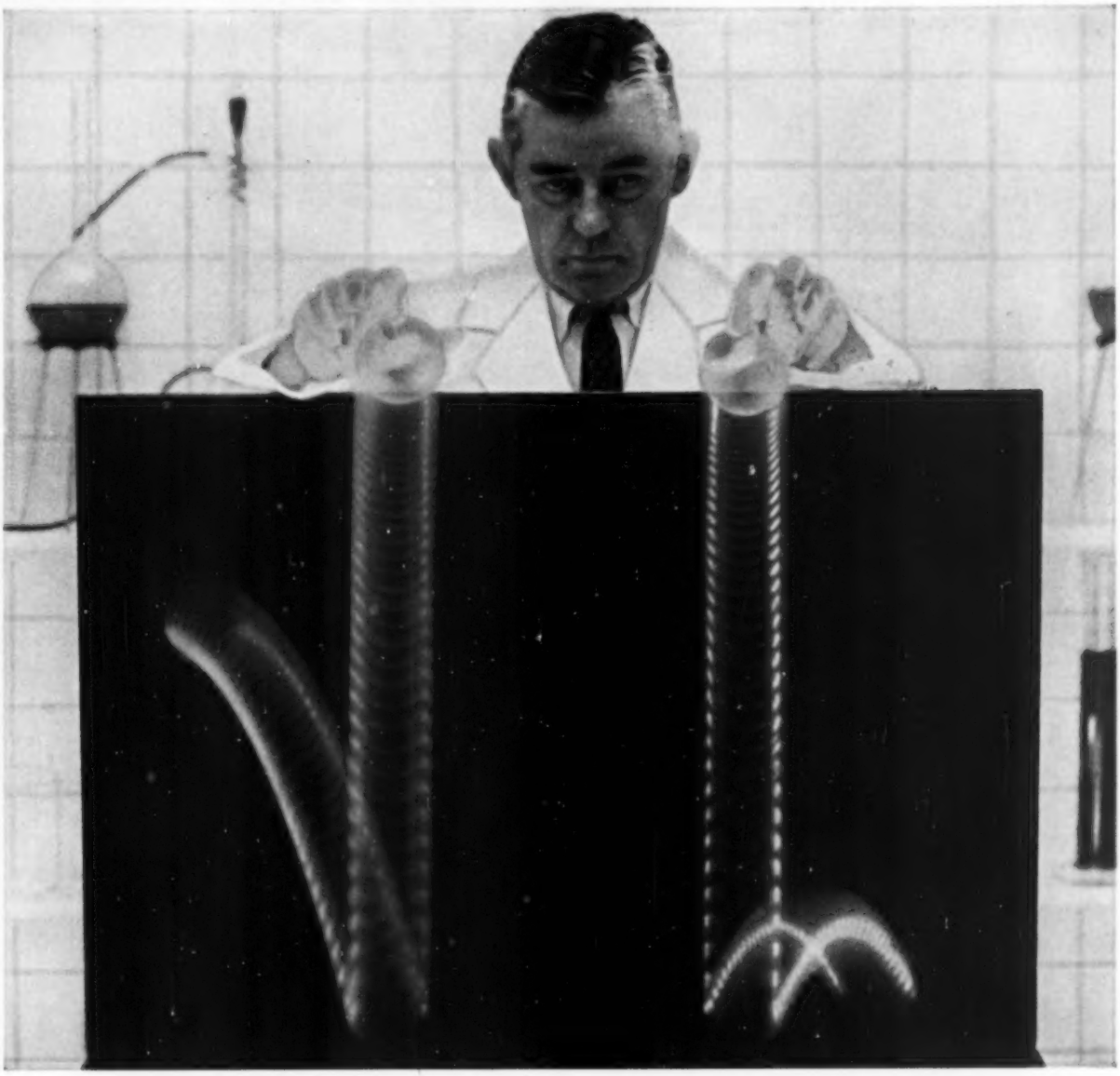
precision needle roller bearings

Send for free copy of McGill Bearing Catalog No. 52-A.

MULTIROL®-GUIDEROL®-CAMROL®-CAGEROL®

McGILL MANUFACTURING CO., INC., Bearing Division
201 N. Lafayette Street, Valparaiso, Indiana

What's News in Rubber...



Enjay Butyl smooths the bounce out of bumps!

For built-in shock absorption and damping, Enjay Butyl has proved to be outstanding in product after product. The illustration above shows why. Unlike ordinary rubber (red ball) which shows extended bounce when dropped, Enjay Butyl (blue ball) absorbs shock with almost no bounce at all! Results—in automobile engine mounts and axle bumpers – greater shock absorption for smoother rides; in tires – road-hugging performance, quieter, safer stops and no squeal even on sharpest curves.

In addition, Enjay Butyl offers many other outstanding properties such as impermeability to gases and resistance to chemicals, heat, weather, ozone and aging. In addition to Butyl, there is new Butyl Latex and Butyl HT-10-66 (halogenated for high heat resistance and faster cures). In rubber, plastics, chemicals and oil additives, chances are that Enjay has the product to solve your problem. Write to us at 15 West 51st Street, New York 19, N. Y.

EXCITING NEW PRODUCTS THROUGH PETRO-CHEMISTRY

ENJAY CHEMICAL COMPANY

A DIVISION OF HUMBLE OIL & REFINING COMPANY

ENJAY

CIRCLE 69 ON READER SERVICE CARD

FROSTWOOD

. . . molded articles of Pelaspan offer

An exciting new dimension of *texture* is captured in *Frostwood** molded articles . . . produced by injection molding Pelaspan® expandable polystyrene beads. *Frostwood* molded articles have a distinctive swirled texture reminiscent of rich, fine wood grain. Because the wood grain pattern never repeats itself exactly, every article becomes an original.

*TRADEMARK

a foam core with a hard, textured skin!

The ability to create *Frostwood* molded articles offers designers a vast, untapped potential for products of every description . . . for housewares, such as carafes and thermal tumblers . . . furniture parts, such as chair backs . . . appliance shells . . . and for other design applications where appearance is a major consideration.

Frostwood molded articles are made by injection molding Pelaspan expandable polystyrene beads. A special technique produces molded articles having a lightweight core of foamed polystyrene with durable, shock-resistant, textured surface. *Frostwood* articles offer high thermal insulating efficiency, plus unique one-of-a-kind texturing which gives *Frostwood* molded products eye-catching, sales-making beauty.

Frostwood molded articles can be produced from Pelaspan by a special technique, on most standard injection molding equipment. There are few limitations on shape and contour. Here are almost unlimited new product design possibilities!

Dow Plastics Technical Service Engineers will help you adapt this material to your design problems. Write us today in Midland, C/O Plastics Sales Department 1722DZ11-13.

THE DOW CHEMICAL COMPANY DOW Midland, Michigan

ELECTRIC SHOE BUFFER by Royal Master. Styron® plastic offers wide color range, high impact strength and light weight to this unique product.

ELECTRIC CAN OPENER by Westinghouse. Colorful housing of Styron plastic combines excellent moldability with food and chemical resistance.

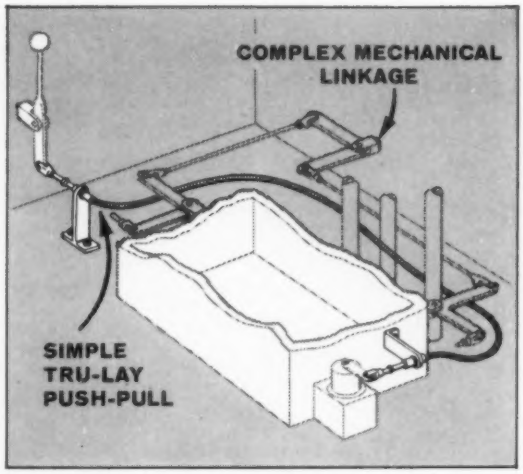
EXHAUST FAN by Berns Air King. Grille of high-impact Styron plastic resists shock and vibration. Grease and stains wipe clean in a jiffy.

CIRCLE 71 ON READER SERVICE CARD

TRU-LAY *PUSH*-PULL CONTROLS PROVIDE

Dependable Economical Easy-to-Use REMOTE CONTROL

• If your products involve remote control—electrical, hydraulic, pneumatic or direct—TRU-LAY PUSH-PULL FLEXIBLE CONTROLS can help solve your design problems. They provide positive remote control over long or short distances—up to 150 feet from the control point. Because they operate while flexing, they can snake around obstructions. They will not buckle. They're factory-lubricated for life, unaffected by temperature extremes. They are ruggedly constructed, easily installed and operated, sealed against dirt and moisture, and will handle jobs with as much as 1,000 lbs. input. PUSH-PULL CONTROLS are simple, have but one moving part, are noiseless, and give a lifetime of accuracy. Mechanical linkages, on the other hand, are complex. Unlike PUSH-PULL CONTROLS, they are made of many parts, wear at many points, and produce increased backlash, lost accuracy, and vibration rattles.



CABLE SIZES AVAILABLE

Control Dimension	Minimum Recommended Radius in Inches	Maximum Input Load in Pounds (Dependent on Travel)
3/32"	2	30
1/8"	3	65–125
3/16"	5	115–175
1/4"	6	300–600
5/16"	8	700–1,000

PUSH-PULL DATA FILE SHOWS HOW TO SIMPLIFY, IMPROVE DESIGN

• Write for your PUSH-PULL Data File. It contains a complete set of engineering bulletins which describe in detail the operation of PUSH-PULL CONTROLS, their applications, features and advantages.

Operating Heads to Fit Your Design
for loads up to 125 lbs.

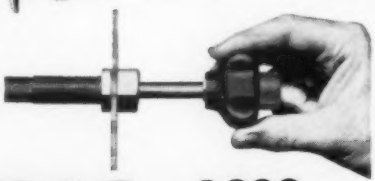
Heavy Duty • For rugged duty, but where operation must be smooth and accurate. Meets all requirements for dependability and life.

Light Duty • Smooth, accurate, dependable performance at low cost. Your choice of several types of knobs.

Selective Friction • Amount of friction can be changed to meet individual requirements. Friction constant at any setting.

Position Lock • A slight turn of the T-type handle locks the control in any position. Two sizes for light and heavy-duty applications.

Micro Control • Push or pull the knob for instantaneous response, then rotate knob for vernier adjustment.



PUSH-PULL CONTROLS

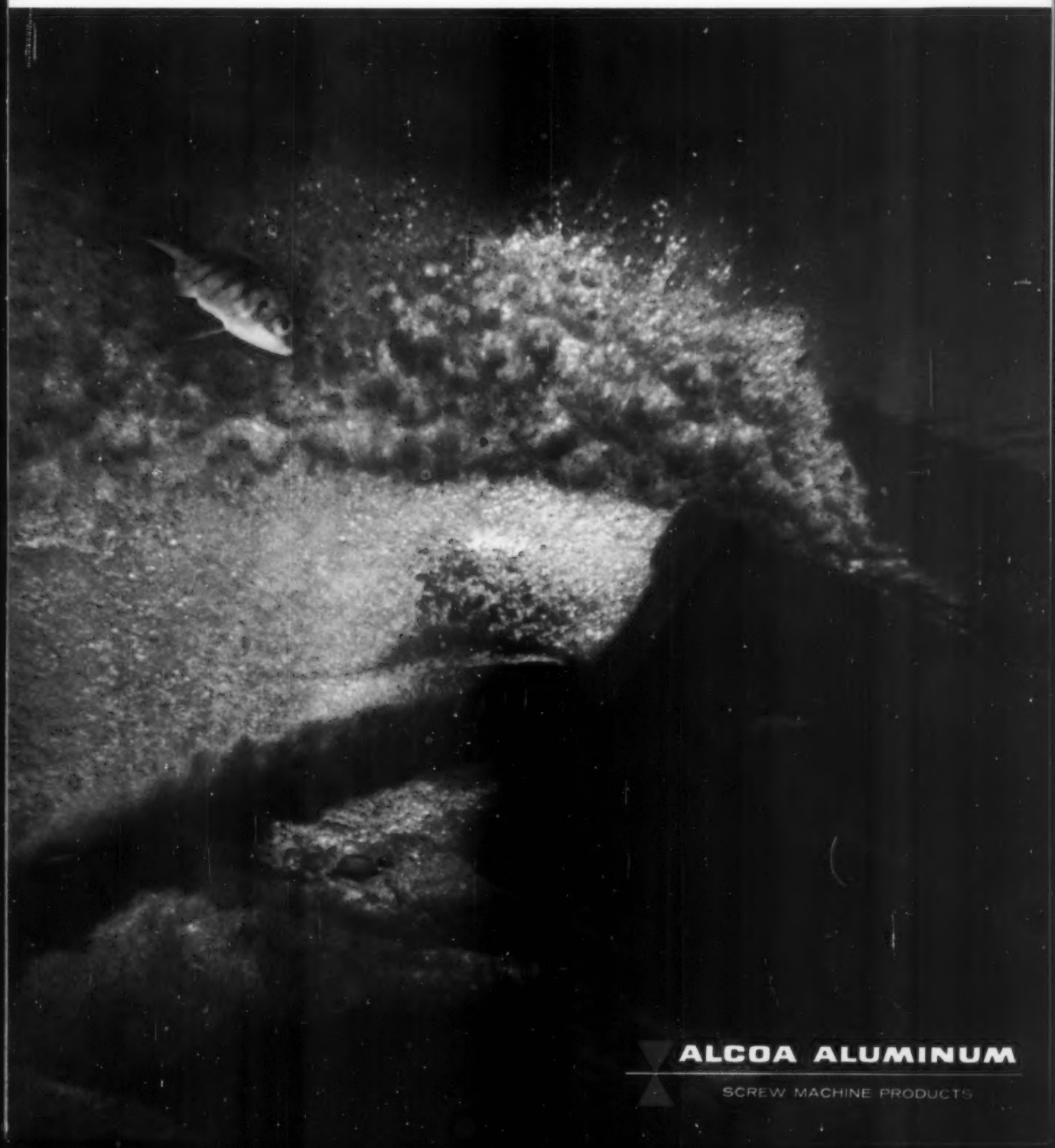
Automotive and Aircraft Division • American Chain & Cable Company, Inc.

601-E Stephenson Bldg., Detroit 2

6800-E East Acco Street, Los Angeles 22 • 929-E Connecticut Ave., Bridgeport 2, Conn.

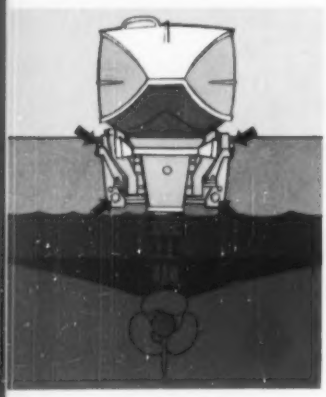
ACCO

When a 1/2" aluminum bolt bears more than a 40,000-psi stress . . .



When a ½" aluminum bolt bears more than a 40,000-psi stress . . . . . .

that's Alcoa Total Ability at work!



Hang a 210-lb outboard on the transom of a frisky speedboat, uncork its 75 horses worth of power and go zigzagging across a choppy sea. Given these circumstances, outboard designers tell us, tension on the engine mount bolts exceeds 40,000 psi.

As insurance that these bolts will never snap, Alcoa furnishes ½-in. x 4-in. hex-head aluminum cap screws that have a minimum tensile strength of 62,000 psi. That's enough reserve strength to stand up under unexpected impact or years of fatiguing use.

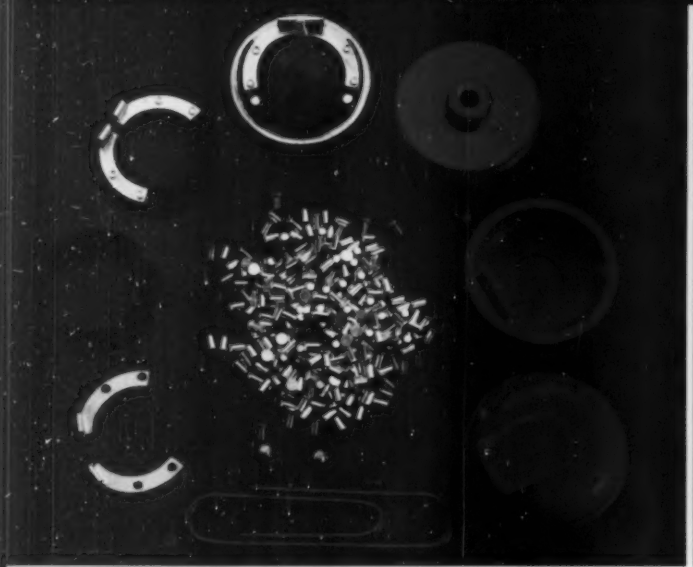
Ir screw machine parts as well as forgings, castings, extrusions and impacts, Alcoa can deliver aluminum in an almost limitless variety of forms, colors, textures, tempers and thicknesses.

Alcoa also produces tough, cold-headed parts like these for vibration-absorbing aircraft-type engine mounts.

Alcoa Total Ability, unmatched by any other light-metals manufacturer, can help you achieve an ingenious design solution, less waste in production or a product that sells better. How can we help you? Call your nearest Alcoa sales office, or write Aluminum Company of America, 857-Y Alcoa Building, Pittsburgh 19, Pa.

ALCOA ALUMINUM
SCREW MACHINE PRODUCTS

TYPICAL COLD-HEADED AND SCREW MACHINE PARTS PRODUCED BY ALCOA



A. Tiny aluminum rivets and screw machine parts for a hearing aid. The paper clip indicates the diminutive size.

B. Alcoa produces and stocks the world's most complete line of standard fasteners.

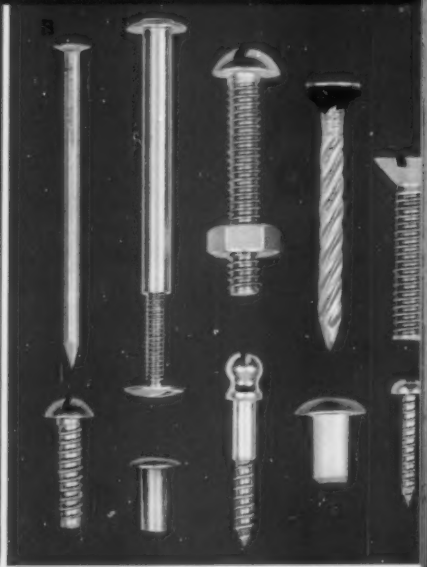
C. Precision screw machine part for military ordnance.

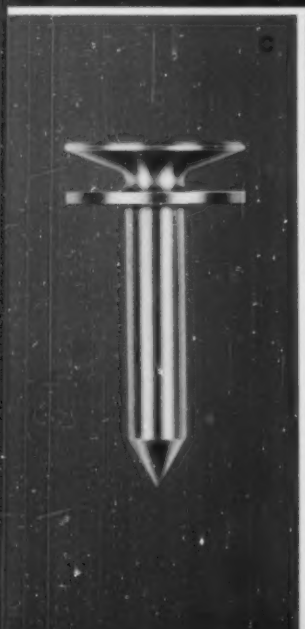
D. Pressure fitting machined from an Alcoa® Impact extruded machining blank.

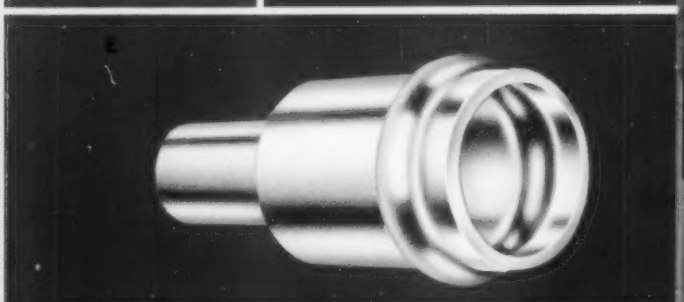
E. Cold-headed automotive distributor cap insert.

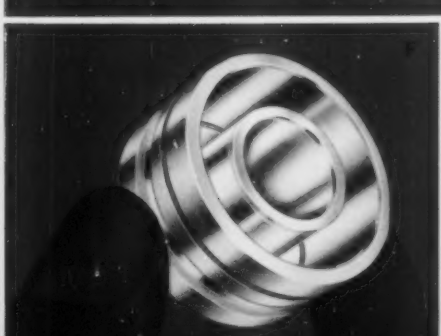
F. Piston for automotive air conditioner.

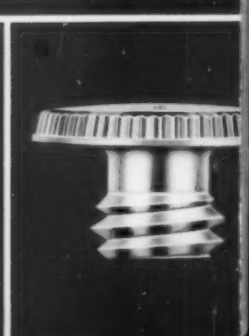
G. Knurled knob for a camera.











DEVELOPMENTS TO WATCH

Bearings are in the news, with two novel—and very different—ideas promising to reduce friction and improve performance.

In the US, the Navy has found a way to get around the lubrication problem by **making the bearing retainers of solid dry lubricants, using heat-resistant fibers for reinforcement.** Result: bearing retainers that are 80% lighter than metal, lower in cost, self-lubricating, and stable from —300 F to 1000 F. The Naval Air Material Center, Aeronautical Materials Laboratory (Philadelphia) is doing the work, under sponsorship of Bureau of Naval Weapons.

A molybdenum disulfide—sodium silicate composition, reinforced with asbestos fiber, was used for the first tests. Now other reinforcing agents (glass and metal fibers) are being tried.

M. J. Devine, E. R. Lamson, and J. H. Bowen, Jr of Aeronautical Materials Laboratory say the retainers can be made in inexpensive molds, with a molding cycle of no more than 8 min. and will stand at least 7 hr at 10,000 rpm and 750 F.

In Britain, an almost exactly opposite technique is giving equally good results. **Hard, abrasive particles, forced into bearing surfaces, are reducing friction and improving load-bearing ability.**

The method: the metal bearing surface is covered with diamond dust and rubbed against an equally hard surface so the diamonds work themselves into the metal. Further rubbing abrades the diamond particles to form rounded pads or bumps which then act as bearing surfaces.

J. Wells of Bradford Institute of Technology, who is developing the idea, says research is still in the early stages. But tests of bronze sliding on impregnated steel show the diamond-impregnated bearing surfaces can stand as much as 300% of the failing load of a conventionally lapped surface, with coefficients of friction on the order of 0.001. Preliminary tests also indicate it may be possible to substitute other hard particles, perhaps silicon carbide, for the diamond.

• • • •

Space scientists are making progress on two far-out problems: solar pressure and "variable-geometry" structures.

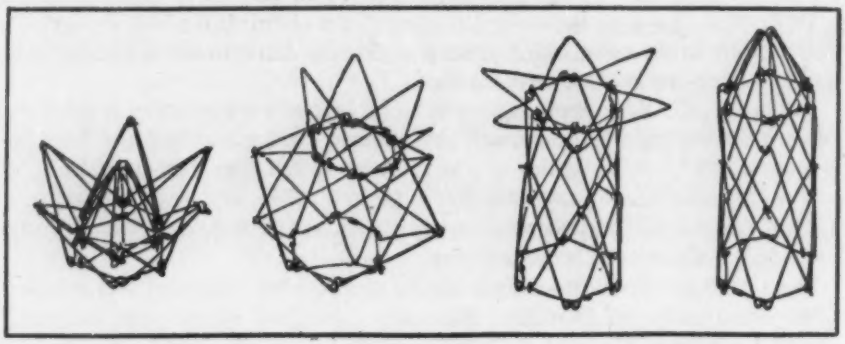
To most people, the pressure of a sunbeam is more figurative than real. Not so to the space scientists. The force of the sun's rays can actually knock a satellite off course and shorten its orbital lifetime. Says R. W. Bryant of Goddard Flight Center: "in the motion of artificial satellites with large area-to-mass ratios, such as the Echo I balloon satellite, the magnitude of the solar radiation pressure effect is substantial and must be taken into account in the analysis of the tracking data."

Several laboratories are now at work, calculating solar pressure and its possible effects on satellite motion and altitude control, and developing designs that will minimize its effects.

The importance to the earth-bound? Studies now in progress are bringing many refinements of vector analysis and throwing new light on the theorems of classical mechanics.

Bryant's latest report, NASA Technical Note D 1063, is available to government contractors from NASA; and may be purchased by others from OTS, Dept of Commerce, Washington 25, DC for 50¢.

All-purpose skeletons for space ships are being developed by Northrop engineers. The aim: to provide structures capable of being fired into space in compact packages and unfolded to a wide range of geometric shapes to form satellites, antennas, and reentry vehicles. It's one aspect of the work on "variable geometry" structures (*PE—Oct* 16, *p* 70) that's expected to provide better control of aerodynamic



and solar heating, greater stability, and better control of lift, drag, and surface area during reentry.

The basic models (see sketch) consist of rings with articulated semicircular or triangular arches. These are combined to produce a variety of structures. A combination of triangular arches with rigid rings of different diameters provides a structure that can fold within itself to form a condensed conical shape. A combination of two rigid rings of the same diameter and circular arches can be made to form spherical shapes of maximum volume and minimum surface area.

• • • •

Electrical engineers are coming up with a host of new ideas that have mechanical as well as electrical applications:

Printed circuits are being stapled at Lenkurt Electric rather than made by the usual etching process. In place of laminated copper foil, they're using low-cost tin-coated bronze wire for the circuits and stapling it in place as needed.

J. M. Coffin and L. B. Johnson of Lenkurt say the system permits automatic or semiautomatic fabrication, offers high reliability and repairability.

Describing the system at an AIEE Wire Communications Systems group meeting, they pointed out that each staple becomes the termination for one or more nearby components, and component leads and connecting wires are wrapped firmly around the staple legs, providing excellent mechanical and electrical connections even before soldering, so boards can be tested while it's still easy to make changes.

Etched-foil aluminum electrolytic capacitors that can compare favorably with plain-foil tantalum capacitors in cost, volume, and maximum working voltage are being developed at Telegraph Condenser Co (Canada).

F. J. Burger and D. M. Cheseldine of TCC have been working on them; told the Canadian IRE they show promise for wide-range operation: —70 to 250 F. Major aim of the work was to develop (for the Canadian Defense Research Board) a wide-range capacitor using nonstrategic materials. Now, TCC believes it has the answer, though further evaluation is needed.

Track resistance of dielectrics used for cable insulation is tabulated by N. Parkman of the British Electrical Research Assn in a report prepared for the Plastics Institute. He uses a *comparative tracking index* which is a function of the minimum voltage at which the carbonization that creates conductive "tracks" across the material occurs. Polycarbonate has an index of 110; polypropylene, polystyrene, and polyethylene all have indexes in excess of 500; and even cable paper shows an index of about 200. Parkman notes, however, that polycarbonate's relatively poor discharge resistance is compensated to some extent by its greater resistance to solvents such as those used for cable impregnation.

An electrical test instrument that locates electrical discharges in switches, capacitors, insulators, and cables during normal operation has been designed by Addison Electric Co Ltd of Britain. The instrument is called an acoustic corona detector, and it works by **detecting the sonic vibrations** these electrical discharges create.

The unit consists of a **probe** that contains an electrodynamic vibration detector; a **receiver,** containing a transistorized 5-stage amplifier, battery, indicating meter, and loud-speaker; and a set of **stethoscope earphones,** with a miniature electromagnetic ear piece. The probe is fitted with a metal stylus to make point contact with the item under test, and the reciever has a selector switch that allows choice of wide-band characteristics or a high-pass filter to reduce low-frequency interference.

In operation, the probe is simply held in the hand and applied to the part under test at several points until a maximum response is received. This is the point of discharge—the point at which the vibration or sound wave reaches the surface.

The entire unit weighs less than 6 lb, comes complete with its own leather carrying case, screened coaxial leads and plugs.

• • • •

Heat resistance continues to get a lion's share of attention, with new questions as well as new answers cropping up:

Fasteners are posing new problems for heat shield designers.

Tests at NASA's Langley Research Center indicate that graphite heat shields, with and without insulation, survive simulated aerodynamic heating at temperatures at least to 2840 F, with dynamic pressures of 5500 to 6000 psi and jets of mach 2 speed.

The graphite shield alone cuts heat buildup on the base by nearly 50%; and, with insulation, base structure temperature is still less than 500 deg after 2-min. exposure in a radiant heater test which brings the outer surface of the graphite close to 2000 F. There was some loss of surface material from the graphite on repeated cycling, but performance generally was good.

With the fasteners (zirconium dioxide, with stainless bolts for attachment) it was a different story. Not only did they fail by spalling but their failure resulted in a flutter that destroyed the shield.

Several types of insulation were tested: a bulk fibrous ceramic material, a radiation shield made of corrugated gold foil, and a composite blanket with alternating layers of gold foil and glass fiber felt. They seemed about equally effective.

Multipost heat shields and stainless steel tile heat shields were also tried, with the former proving superior to the latter in retarding heat flow to the base. But these structures are relatively complex and need further study.

Fabrication problems continue to plague rhenium, the "new" high-temperature metal (*PE—Mar* 17 '58, *p* 66). But the Navy sees at least one ray of hope. NRL has found a way to consolidate the metal and roll it into sheet, using arc melting, pressing, and cold rolling.

Surprisingly little difficulty was encountered in the arc melting stage. Despite the high melting point of rhenium, melting was accomplished easily enough at 500 amp and 25 v. The surface of the buttons had an excellent appearance with a very bright metallic lustre and no indication of gas evolution during solidification.

But, the cold working of rhenium is still a tedious process, requiring multiple small reductions, each followed by a stress relief anneal at very high temperatures in a very pure environment.

New welding processes aimed at high-temperature materials are showing limitations as well as advantages. DMIC notes, for instance, that **plasma-torch welding,** expected to be especially valuable for the refractory metals, is posing a number of problems in application.

It was hoped that the high heat (15,000 to 30,000 F) and high purity of the plasma jet might eliminate the major problem of tungsten inert-gas welding (grain

growth), and the very high vacuum environment necessary for electron-beam welding. But, high-velocity plasma jets caused severe weld spatter, and low-velocity jets reduced welding speed and eliminated most of the advantages as compared to conventional welding.

Stanford Research Institute, which made the tests, feels the jet systems could be modified to overcome these limitations, but much remains to be done.

Meanwhile, speakers at the American Welding Society Convention confessed to some disenchantment with electron-beam welding. On refractory metals, R. E. Roth and N. F. Bratkovich of Allison said, electron beam welding does provide greater strength—as much as 20% more than tungsten-inert-gas at 1600 to 2000 F on molybdenum alloy, for instance. But they say the electron-beam process does not markedly enhance the weld strength of conventional materials. Tests on air-hardenable steels showed little if any advantage for the process. Other speakers did note, though, that electron-beam welds in titanium alloys, mild steel, stainless, and hot-worked die steel are more ductile in most cases; and moderately ductile welds have been made in tungsten with far less heat input then would be required for comparable inert-arc welds.

• • • •

Better anti-icing systems may result from a study now underway at Naval Research Lab. A good many factors have been found to influence the degree of ice adhesion. But, says NRL, one of the most important is the **contact angle between the water droplet and the oil-covered surface.** It's a factor that has received the attention. NRL tests show adhesion can be substantially reduced if the angle is high enough to minimize oil displacement by the water—160° or more. (In tests of force required to remove ice buttons, those formed by water droplets at an angle of about 150°, required nearly three times as much force to remove as those formed from droplets at 170°.)

Contact time before freezing is important too; and, of course, the viscosity of the oil plays a major role. Viscosity shouldn't be too high, though. Oil that is too viscous may act as an adhesive between ice and metal, impeding ice removal. In general, NRL recommends, the oil film (or any other liquid, gas, or solid interposed between the water and the metal surface) should have high shear-sensitivity to prevent establishment of intimate contact between the two.

Oil additives which cause the oil to form unstable emulsions with melting ice crystals and which make the water drops "ball up" instead of spreading out, can also be helpful.

Another interesting finding: oil is even more helpful in preventing ice adhesion to such materials as Teflon (the fluorocarbon plastic) than to metal. Normally, ice has less tendency to adhere to Teflon than to clean metal. But, when the Teflon is coated with oil, water adhesion is reduced practically to zero. The reason: Teflon appears to attract and hold the oil much more strongly than metal does, thus minimizing displacement by the water.

If you'd like a "new" anti-icing compound you can use right now, take a look at urea. This old reliable chemical, the first organic ever synthesized in the laboratory, is turning out to be remarkably effective in preventing ice formation. DuPont says it not only melts ice (it lowers the freezing point of water to 11.5 F) but also eliminates many of the corrosion problems encountered with sodium and calcium salts. Furthermore, DuPont says, it's electrically nonconductive so it can be used on open power lines like transit-system third rails. It's cheap enough for large-scale use, too, and readily available. It's sold in 100-lb bags, in shotted and crystalline form. **—ARG**

From the nuclear field–

Isotopes for design jobs

Those activated atoms are versatile indeed. From piston-ring wear studies to determination of optimum coating thickness, they are valuable design tools.

ANNESTA R GARDNER, associate editor

NO matter what kind of product your company makes, chances are there's an engineering problem in your shop right now that radioisotope techniques can solve better, faster, or cheaper. They may not always be simplest—sometimes a good deal of special equipment may be needed. But, there is always the possibility of subcontracting the complex part of the work; in that way, you need not even bring the isotopes into your plant.

Isotopes can measure surface roughness, determine distribution of lubricants, gage concentricity, and check performance of fully assembled mechanisms. They can be used to "weigh" parts and measure thickness. They can monitor the height of liquids and help probe the depths of long channels and depressions. They can detect leaks and indicate porosity.

The versatility of radioisotopes stems from the fact that they are unstable atoms—atoms which break down or decay at a predictable rate, giving off energy in several forms as they do so. This energy can be used to activate phosphors and produce visible light, supply the hot junction of

KING-SIZE WEAR STUDY at Standard Oil of California applies radioisotopes. Radioactive piston ring is installed in diesel, then oil and exhaust gas are monitored with radiation detector to see how much radioactivity is worn off. Filter from exhaust gas line is also checked, by placing it in counting chamber sensitive to 0.000,01 oz of wear.

20 ways you can use isotopes

Here's a brief rundown of applications for radioisotopes that are already in practical use or advanced development. They can provide new methods for:

- WEIGHING
- TIMING
- THICKNESS AND DENSITY MEASUREMENT
- CORROSION MONITORING
- POROSITY DETERMINATIONS
- CONCENTRICITY MEASUREMENTS
- PART LOCATION
- FLOW MEASUREMENT
- LEVEL-GAGING — LIQUID, SOLID, OR SLURRY
- MONITORING PROCESSING OPERATIONS — MIXING, GRINDING, CHEMICAL REACTIONS
- LUBRICATION AND WEAR STUDIES
- LIGHTING AND MARKING
- ELECTRICAL POWER PRODUCTION
- HEAT GENERATION
- X-RAY
- SURFACE-ROUGHNESS MEASUREMENT
- ALLOY IDENTIFICATION
- DATING AND SHELF-LIFE DETERMINATION
- STATIC ELIMINATION
- PARTICLE-SIZE DISTRIBUTION

thermoelectric devices, ionize gases, and promote the flow of electric current in battery-like devices.

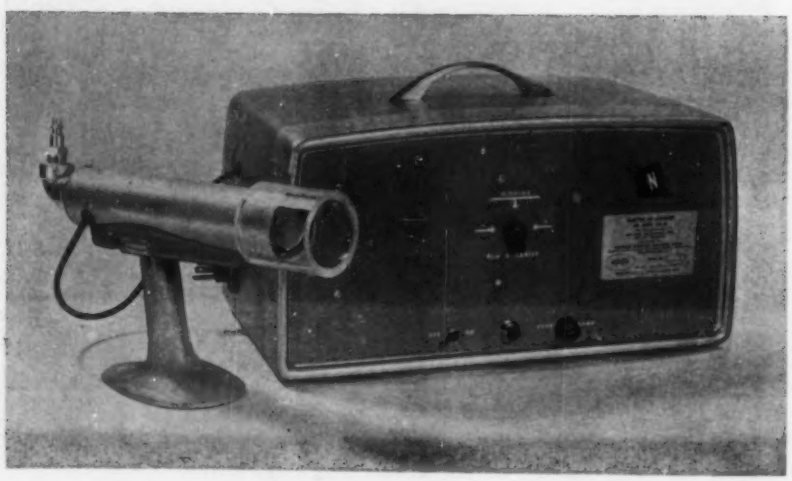
And you can fit the atom to the job. Where the isotope is to be incorporated in the product for production purposes (checking alignment of parts after assembly, for instance) a strong, penetrating radiation may be desirable. But the activity should be short-lived so it will substantially have disappeared before the product is shipped.

For instruments, batteries, lights, and other uses, on the other hand, a long-lived and perhaps "weak" isotope may be the most desirable.

In many cases, there are several ways to apply isotopes to a specific problem. Suppose, for instance, it is desired to check location of a part inside an assembly after the unit is completed and sealed. One way to do it is to X-ray the part, using isotopes as a convenient X-ray source. Another way is to paint the part with a short-lived isotope before assembly, then check afterwards with a radiation detector to determine its location. The third way is to apply the thickness or concentricity gage technique—sending a beam of radiation through the assembly. If the part is properly located, the beam will pass through it, and much of the radiation will be absorbed. If the part is off-center, and the beam does not hit it, a larger amount of radiation will be received by the detector.

Another example of the multiple

How they can add new values and bring new life



possibilities for isotope applications comes from an AEC-sponsored study by H. J. Rose of Bituminous Coal Research. For identifying and counting mine cars, he suggests small rivets containing a trace of radioactive metal —just enough to operate a gamma relay. One of the special rivets could be set into the corner of each mine car, at different heights depending upon the mine area to which the car was to be sent. As the mine car enters the dumping area, radiation from the rivet would enter the appropriate radiation receiver and actuate the proper relay for shunting and counting the car.

As an alternate method, a directed beam of gamma radiation and a radiation detector might be located on opposite sides of the haulage way. As mine cars intercepted the beam, the counting device would respond or an operating sequence could be initiated.

The field is still wide open for development of new products using radioisotopes.

For example, isotope-assisted operation has only begun to be explored.

U. S. Radium is working on a system for stabilizing firing time of cold cathode tubes, without increasing applied potential, by using radionickel as an ionization "trigger."

Nuclear timers which use charge buildup on a nuclear "battery" as a timing function are already available. Now isotope-assisted fuel cells are under test. Preliminary reports indicate

What the terms mean

Atom: The basic building block of nature and the smallest particle which has the recognizable, individual characteristics of an element. The atom consists of a nucleus or core, itself made up of particles known as neutrons and protons, surrounded by a "cloud" of one or more electrons.

Isotope: Any one of several forms of an atom, identical in chemical and most physical properties; but differing in the number of particles in their nuclei, and therefore differing in weight. In some cases, the "extra" or "missing" nuclear particles result in instability. The atom tends to break down, emitting various types of radiation as it does so. Unstable atoms of this type are called radioactive isotopes or radioisotopes.

Radioisotope: An unstable form of an atom, in which the nucleus tends to break down or "decay," forming smaller (lighter) atoms and giving off various types of radiation — alpha, beta, and gamma.

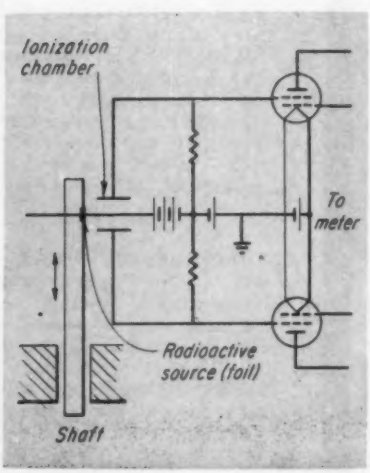
Alpha and beta radiation: These "rays" emitted by radioisotopes are actually small atomic particles; the alpha radiation being stripped-down helium atoms; the beta being streams of electrons.

Gamma radiation: This electromagnetic isotope radiation is essentially similar to X-rays, and is the most penetrating of the three.

Protons and neutrons: These are the primary nuclear components, apparently identical, except that the protons are positively charged; the neutrons are neutral.

Half-life: Although all unstable isotopes eventually break down, they do not all do so at once. Of the unstable atoms in a given group, a certain number will break down in a given period of time. This period is characteristic for each isotope. To measure it, the term "half-life" has been adopted. This is the period of time in which half of the atoms of a given element in a given group will decay. For some isotopes, the half-life is very long—thousands of years. For others, it is a fraction of a second. Half-life is important because it determines how often isotope instruments will have to be calibrated, how long "batteries" will last, and how soon unwanted radioactivity will be minimized.

to your product



STATIC ELIMINATORS like the US Radium ion generator at the far left take advantage of isotope's ionizing ability. The generator uses radiokrypton to produce ionized beam for static elimination. This product, like the lamp (center) is fully commercial, and available in several models.

ISOTOPE SWITCH LAMP (center) looks like any other, but requires no external power source. Radioactive krypton, sealed in small glass bulb, activates phosphor coating to produce light. This US Radium lamp, with 4-in. reflector, has visibility at least to 1500 ft, is available in 4 colors. Radioisotope lanterns and flashlight are also made.

ISOTOPE SERVES AS POSITION INDICATOR in this design. When shaft moves up or down, radioactive foil is carried out of ionization chamber range and current in circuit is cut off. The system may also be adapted for weight determinations—to monitor the movement of a scale balance arm.

How to detect isotopes

You can't see an activated atom. But you can make it take its own picture—by exposing it to an X-ray plate. Or, you can detect its presence with any one of several instruments that take advantage of isotope ionization and charge-buildup effects. Among these are ionization chambers, Geiger-Mueller counters, spark counters, scintillators.

Ionization chambers consist basically of two electrodes, surrounded by a gas, and maintained at a potential difference; plus some sort of measuring device. When an "ionizing event" —that is, a beam of radiation from an activated atom—occurs, positive and negative ions are formed, causing a current to flow between the two electrodes. This flow of current signals the presence of an activated atom, and can be monitored, with a count of the individual pulses indicating the number of activated atoms present.

Geiger counters are a special type of ionization chamber, designed to produce an "avalanche" effect that considerably enhances output. The Geiger tube has a gas-filled tube that serves as a cathode. A centrally located fine wire is the anode. When a high-speed atomic particle enters the tube, electrons are dissociated from the gas. These, in turn, dissociate other electrons in an avalanche or chain reaction that results in high concentration of electrons at the central anode.

Spark counters are also ionization chambers, but are so designed that the ionization produces a series of electrical sparks, which are then counted and recorded.

Scintillation counters, too, utilize the effects of isotope radiation. But here, it is the ability of the isotope to activate a phosphor that is the indicating means. A phosphor (often incorporated in a plastic disk, but sometimes in the form of a liquid); a photomultiplier, plus an amplifier and timer, are combined in devices of this type.

that, by replacing the conventional catalyst with a radioisotope, incorporated in the electrodes, it is possible to achieve higher capacity at lower polarization values.

The importance of isotopes as a heat source should not be overlooked. The Martin-designed unmanned weather station now in operation in the Arctic, like the Royal Research underwater unit pictured on p 84, uses isotope heat to operate a thermoelectric energy converter. In the Martin unit, the converter charges nickel-cadmium batteries which power the station's radio transmitter. The isotope "fuel" is contained in a cylinder just 5 in. high and 2 in. dia. But it gives off enough heat to maintain the hot junctions of 60 lead telluride thermocouples at 800 F—and produces enough excess heat to maintain the entire unit at 70 F though it's buried in the permafrost. Output of the unit, incidentally, is 5 watts at 4 volts dc (converted to 28 volts to charge the batteries) and the cold junction temperature is 140 F. Now, a larger weather station is being built. It will produce 250 thermal watts, for conversion to 10 electrical watts.

It is in applications like this—to supply power in remote locations where maintenance is difficult or impossible—that radioisotopes are expected to find their first big jobs. The Royal Research unit, for example, is expected to power an seismograph station located on the ocean floor, at depths to 20,000 feet—and to operate continuously for many years.

But special situations like these are by no means the only way to use isotopes in product development. In many cases, they can profitably be applied to conventional jobs.

At Wantage Radiation Laboratory in England, radioisotopes have been applied to the conventional type of gas flow-measurement device having a

Six ways

1 **FLOW - MEASUREMENT,** liquid-level, and density gages all work like this. Source is mounted at one side of unit being monitored; detector on the other. Amount of radiation that gets through indicates level, amount or density. This is a Nuclear-Chicago setup. For liquid-level monitoring, system would be set up so liquid rising above predetermined level, sets off alarm or shuts off feed.

2 **PROCESS - CONTROL** system uses isotope density monitor. This classic example shows how packing of cigarets may be controlled. Radiation passes through cigaret and standard, is picked up by twin ionization chambers, displayed on electrical control unit.

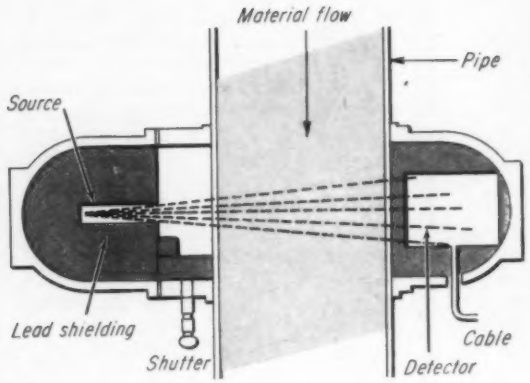
3 **THICKNESS** of materials, or of coatings on them, may be measured by direct-through (transmission) or by backscattering (reflection) method. Transmission gage (above) is more accurate and more sensitive, can be used for fairly thick sections. Backscattering gage (below) is less accurate, limited to thinner sections; but has the advantage of one-side operation. These are UKAEA diagrams.

4 **CONCENTRICITY** may be gaged, as thickness is measured, by intersecting beams of radiation. If outer tubing is off center, too much or too little radiation will get through.

5 **EROSION AND WEAR** can be monitored in several ways. One is a variation of the thickness-measuring technique. As material thickness or density is lowered, radiation penetrates it more readily. In another technique, sketched here, radioactive "pins" are embedded in furnace. As surface erodes, they are exposed, dissolve in melt, are detected in outflow.

6 **COMPRESSOR WEAR** is tested in this Frigidaire setup Here, activated working parts are used; wear is measured by checking radioactivity of oil. Test vanes are inserted in shielded test unit through opening at front; oil sample is being withdrawn at the side.

to measure and test



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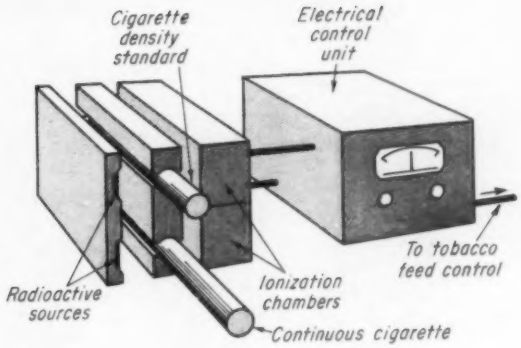

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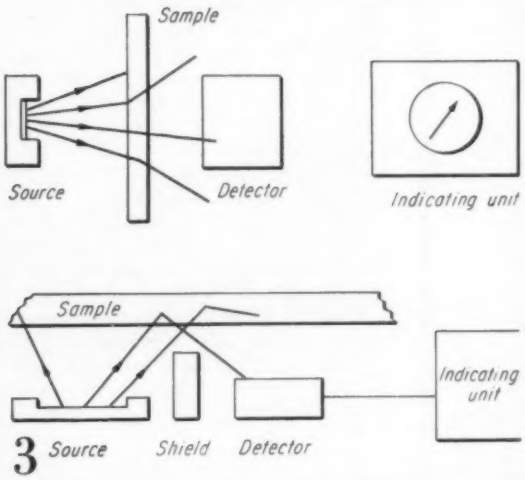

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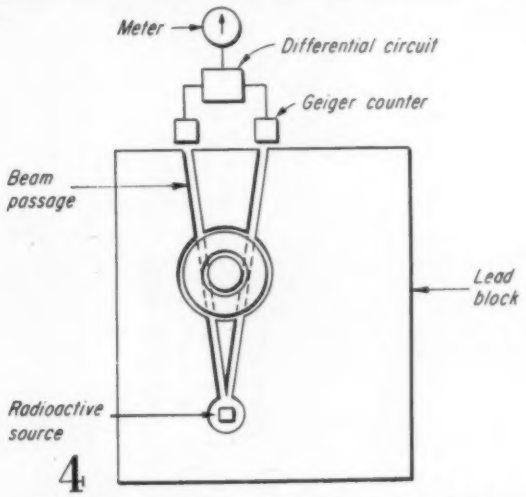

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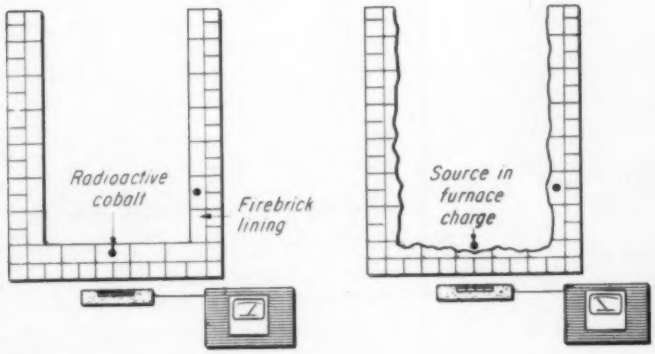

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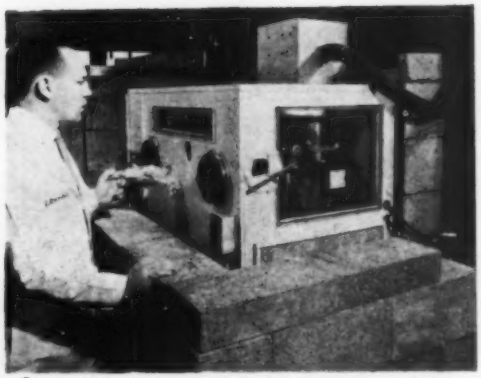

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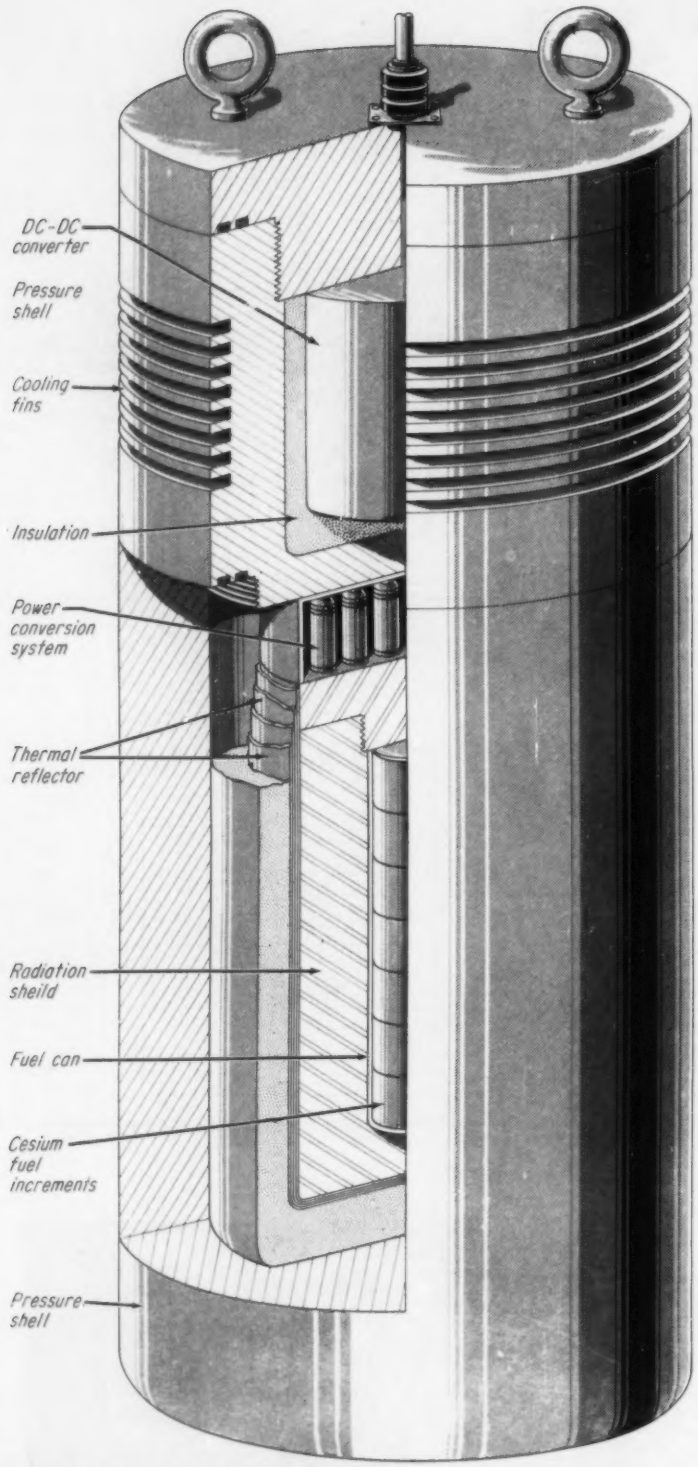


ISOTOPE-POWERED THERMOELECTRIC GENERATOR designed by Royal Research uses radiocesium for "fuel," has lead telluride conversion system, is designed for undersea use. Cesium 137 was chosen because it has a relatively long half-life (27 yr) can be fabricated as a very low solubility polyglass. Fuel "core" is built up of separate disk-shaped elements. Unit shown here has 5-watt output, will supply power continuously for 3 to 10 years.

hinged "gate" suspended in the fluid. By attaching a radioactive source to the lower edge of the gate, and installing a detector outside the pipe to monitor its motion, a flowmeter has been constructed that seems capable of operating under extreme conditions of pressure. It can be made sensitive to very low flow rates.

New York Central Railroad, in cooperation with Tracerlab, developed a car-weighing scale that represents a king-size application of the thickness-measurement principle.

A radiocobalt source is located under the tracks, and a scintillation counter suspended above them. Since absorption of radiation is a function of density of material, the amount of radiation that gets through is an indication of the amount of material in the car. By feeding this data to a computer, along with information on the specific material contained, the total weight of the car is readily determined. The system is still in the developmental stage; but New York Central has estimated its total cost would be no more than $25,000, as compared to more than $100,000 for conventional instrumented scales.

NYC is also using isotopes to study water penetration and oxidation of signal wire, measure diesel engine wear, and inspect railroad ties.

And Esso Research engineers have devised a system whereby a radioiron source and detector are used for billing customers for hydrogen sulfide gas. The system, incorporated in hydrogen sulfide delivery lines, will monitor sulfur content and provide a continuous record of amount delivered. This can be used for billing, just as an ordinary meter record is.

The number of ways in which radioisotopes may be put to work is almost limitless. The BCR survey of possible applications in the coal industry, for instance, found more than 100 practical suggestions, of which more than 80 are already in use somewhere in the world. About half of these are ready for routine applications by nontechnical personnel. Among them: density gages, level controls, recognition and counting devices. The other half are ready for use, but still require specially trained personnel to handle them. Among these are applications involving flaw and corrosion detection, wear measurement and chemical analysis.

They won't do everything

But the coal study also notes that isotopes are not always the best way to accomplish a specific job. For instance, isotope-sensing devices can be

installed on continuous mining machines to maintain a predetermined distance of the cutting head from roof or floor rock. However, mechanical devices, already on the market, are turning in good performance, and may, in the long run, turn out to be the best solution. Similarly, isotope sources are frequently used for X-rays, especially in the foundry industry. But, when X-ray machines are available, they may be preferable for routine inspections of parts and assemblies. They're easier to handle, may provide clearer pictures.

Where to start

How, then, can you find out where isotopes should and should not be considered? How do you get started in this isotope business?

For nuclear batteries, timers, level and density gages, light bulbs and markers, the answer is simple: Just contact the manufacturer. Procurement is little different from that of standard products. Before you start using isotopes in research, though, you'll want to check the Atomic Energy Commision Office of Isotopes Development and take advantage of the many useful government publications on isotopes available through Office of Technical Services, Department of Commerce, Washington 25, DC. OTS has a number of special publication lists, and several special reports such as the 176-page *Radioisotopes in Science and Industry*.

Industry, too, has a great deal of helpful published information. Over 160 companies now make nuclear instruments and many of them have excellent catalogs containing a good deal of background information. Among them: Isotopes Inc., Nuclear Chicago, Ohmart, Tracerlab, US Radium. Many organizations, too, have good primers on radioisotopes. The National Industrial Conference Board is one example. A glossary of *Terms in Nuclear Science and Technology* has been published by the American Society of Mechanical Engineers. Information is also available from atomic energy agencies in other countries. For example, Atomic Energy of Canada, Ltd has an excellent radioisotope manual.

For those who really want to explore the subject of isotopes in depth, the AEC offers a special 4-to-6 week *Radioisotopes Techniques Course for Engineers* at Oak Ridge several times a year. (Information on this and other courses may be obtained from: Special Training Div, Oak Ridge Institute of Nuclear Studies, PO Box 117, Oak Ridge, Tenn.)

Isotope credits and debits

In engineering design and research, radioisotopes . . .

offer these advantages . . .	have these limitations . . .
High sensitivity and detectability for chemical analyses	Resolution may be limited Less sensitivity for weight and level measurements Too much sensitivity for some control applications
Ability to trace elements too small to be seen	There may be some problems in "resolution"—in separating signals received from adjacent areas.
Ability to measure without contact	Equipment cost may be fairly high
Ability to activate electrical sensing devices and controls	Loss of radioactivity with time may call for recalibration of some instruments.
Long-life source of power	Nuclear batteries can be very high in voltage; but amperage is low. Devices using isotopes as a heat source for power generation may, however operate at normal levels.
Cool, long-lasting light source	Light intensity is limited
Permanent means of identification and dating, unaffected by dust, humidity, or mechanical vibration	Public relations problems (safety) may be posed by incorporation of isotopes in products, even though level is extremely low

For **reprint** of above article, just check 637 on one of the Reader Service cards found in this issue.

EDITOR'S NOTE: To put isotopes in their proper place, in comparison with other devices which might be used for the same purpose, check back over these articles:

Unconventional Power Sources, June 26 '61, p 57, a diagrammatic review of eight advanced power systems, some of which may compete with, and some of which may cooperate with radioisotope sources.

Tomorrow's Power Sources, June 26 '61, p 51, a broad-range comparison of 14 different power sources, from fuel cells to thermoelectric and thermionic generators, many of which may someday be supplied by isotope heat or isotope power.

Taming Tomorrow's Power Sources May 4 '59, p 28: More on fuel cells and thermionics, plus an examination of power systems based on nuclear reactors themselves—both fission and fusion.

Explosives become portable power packs, Jan 6 '58, p 56, information on a source of power which, like isotopes, offers the advantage of complete portability.

Midget Batteries—Power Paths to New Design, May 12 '58, p 72, a full description of radioisotope batteries and timers, plus information on storage cells of more-conventional design.

Electroluminescence — new area source of light, Sep 15 '58, p 74. Facts on another new way to produce cool light for dials, indicators.

For background on atomic energy itself—both problems and potentials, see: **Atomic Energy: The Facts,** April 14 '58, p 52.

For solderless electrical joint

Wirewrapping saves time

It's been proving its reliability for over 10 years. Here's when and how to adapt this method easily to either breadboarding or mass production.

D S PRESTON and T K HENDERSON, Hughes Aircraft Co, Culver City, Calif.

IF your problem is a common one—permanently connecting solid wire to terminals—and you need a reliable electrical connection at low cost, take a look at the solderless wirewrapping method. It offers uniformity of connection and adaptation to automatic wiring. Important, too—it requires no heat, which might harm heat-sensitive insulation or components.

Wirewrapping is competitive with solder, weld, and crimp. All four have unique advantages and limitations, so it is important to evaluate each job to determine the kind of connection most suitable for that application. Factors determining the best method are:

- Density (number of joints per unit area)
- Reliability
- Adaptability to automatic wiring
- Heat resistance
- Cost
- Contact area

Wirewrapping is particularly suited to interconnections on panel boards in communication, and various computer systems where density of connections is high, and the large number of them means assembly time must be held to a minimum. Up to three wires can be connected to each terminal, and repairs are simple.

Soldering is best for simultaneous connection of multiple terminals on printed circuit boards or other uniformly shaped parts, or where wide contact area or complete metallurgical bonding is necessary. Also, no special terminals are needed, as with wirewrapping, and stranded wires can be used. Because wrapped connections are under tension and the wire tends to relax when heated, soldered connections can take higher temperatures.

Welding is best in microminiature applications where connection density must be greater than wirewrapping can provide. Welding is also necessary where the conection will be subject to temperatures above the melting point of solder. Contact area is small, however, and because low-resistivity materials are tough to weld, special nickel-clad wire must be used. New techniques in percussion welding overcome this material problem, but introduce a new problem of high stress at the connection.

Crimping is best suited for aluminum, stranded, or tinsel wire, or where the joint must be insulated before connecting. Compared to wirewrapping, crimping has a somewhat greater mechanical strength, but both the crimping operation and the completed connection require more space, and so joint density is lower.

How wirewrapping works

When the wire is wrapped around the terminal, both wire and terminal are deformed (see sketch, next page). The mechanical energy stored in the connection by the tension in the wire and torsion in the terminal gradually dissipates with time. However, according to tests and evaluation by the Bell System, the electrical connection is adequate for central office telephone service for 40 years. During this time the joint will mechanically relax and lose about half its original stored energy, yet not more than one connection in 10,000 will show a change in resistance of more than 0.1 ohm.

Engineers at Bell believe that permanence of the connection is a function of both rate of stress relaxation in the components and solid-state diffusion (an exchange of atoms between wire and terminal at points of contact). The extent of diffusion depends upon time, temperature, materials, and mechanical disturbance of joint.

Wirewrapping applications at IBM are such that engineers there have not relied on diffusion to offset the rate of stress relaxation. Paul Totta, senior associate metallurgist, says that neither operating temperatures nor specified life in the field are sufficient for diffusion to have an important effect on the connections in their machines. IBM now wraps 100 million connections a year with a quality performance during assembly of one substandard connection per 200,000.

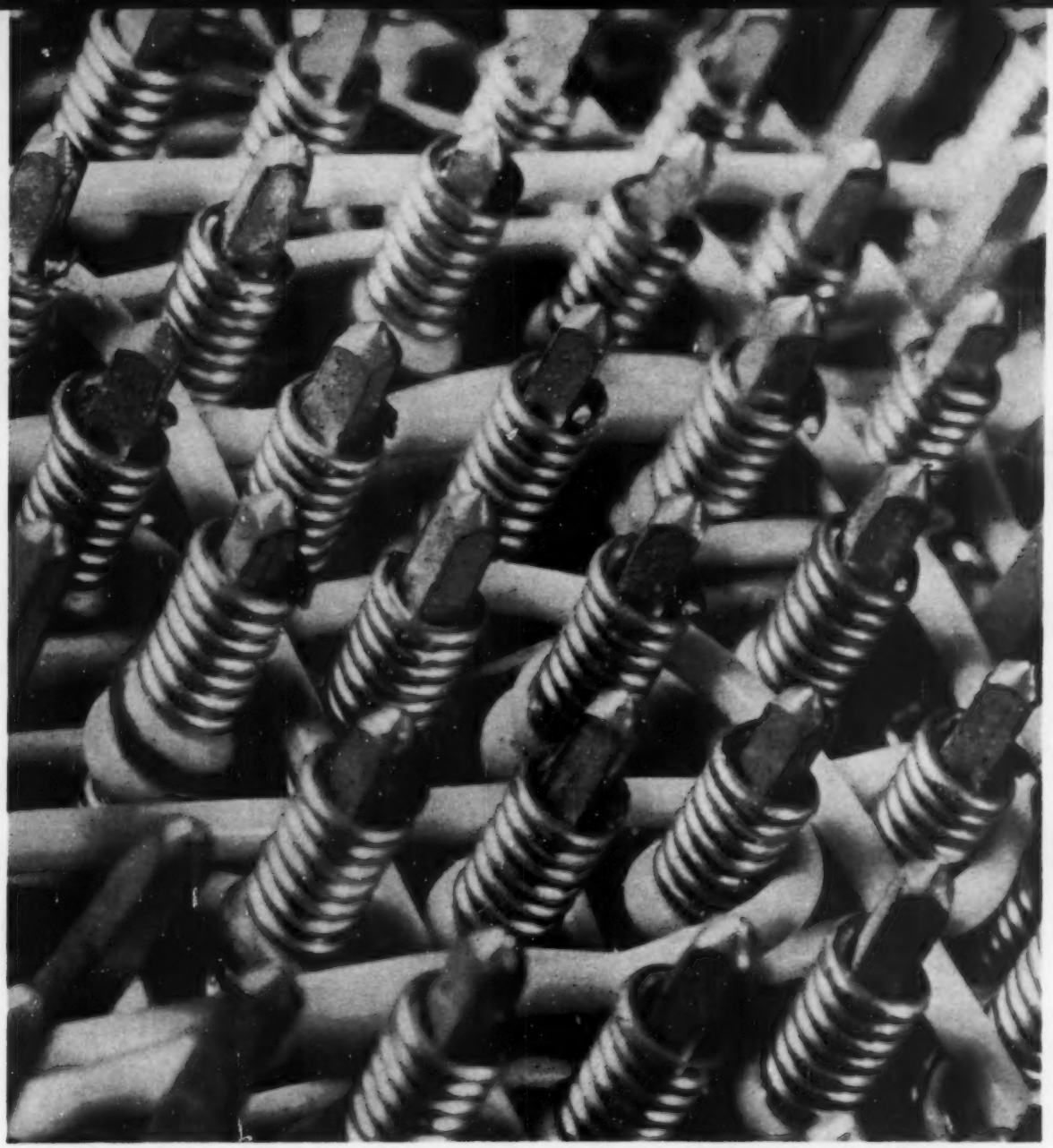
How to use it

Before changing to wrapped connections, a certain amount of preparation is necessary. You need special tools and special terminals, and although neither need be expensive, this does mean setting up for the job. You can prepare for whatever volume required—from breadboarding up to hundreds of millions of connections per year. But sometimes, when it may not pay to modify the terminals of particular equipment, you are better off with the method you now employ.

The kind of wire

Although theoretically all sizes of wire can be wrapped, sizes 26 to 14 gage are practical limits for which standard tooling is available. Wire as small as 29 gage and as large as 6 has been wrapped. But wire larger than 14 is hard to work with because its stiffness requires more force to bend it around the terminal. Also, the ter-

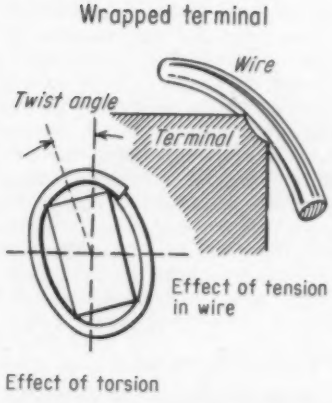
(text continued, page 88)

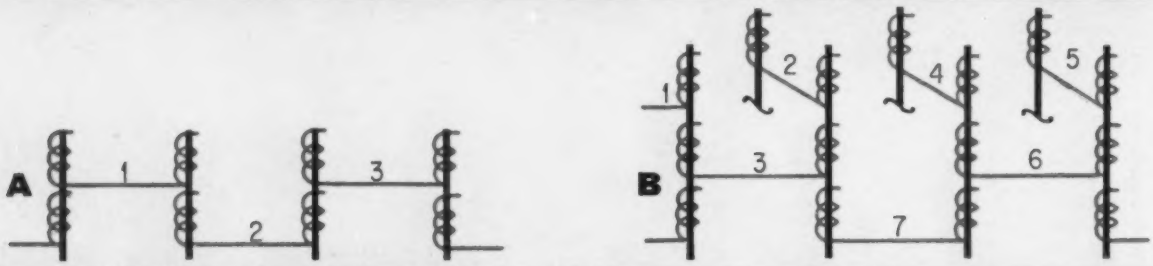


WHAT IS SOLDERLESS WIREWRAPPING?

In this type of electrical connection, the wire is wrapped under tension around the terminal for several turns. The terminal has sharp corners which bite into the wire, holding it firmly in place, and providing a number of contact areas. In contrast to a solder joint, which depends primarily on operator skill and judgment, wirewrapping is done with a calibrated tool.

About 10 years ago the need for a new method of wiring arose in the Bell Telephone System because the terminals of a new relay were so close as to make soldering difficult. Emphasizing the need was the fact that some 50 million connections a year were scheduled for the relay terminals alone. Result: development of the wirewrapping method. Today, the Bell System wraps several hundred million such connections per year.





minal must be stronger to resist this extra force. This requires a larger terminal, but if you increase cross-sectional area, you lose the benefit of high joint density.

Tinned copper is by far the most widely used conductor because it is inexpensive, takes high stress, and relaxes slowly. Nickel-, silver- and gold-plated copper can be used with fluorocarbon insulation for high-temperature applications.

The type and thickness of insulation depends primarily on electrical requirements. But also, because of the sharp corners of the terminals, cut-through resistance is very important, especially when used near the upper temperature limits of the insulation. Chance of cutting insulation can be greatly reduced by proper routing of wires, adequate slack in wire runs, and good operator techniques. Materials for insulation include vinyl, PVC (polyvinyl chloride), nylon-jacketed vinyl, nylon, irradiated polyolefins, Teflon, and nylon-jacketed Teflon.

Terminal dimensions

Terminal shapes are shown in Fig 1 above. They must have at least one but preferably two or more sharp corners that will bite into the wire. Terminal dimensions are affected by:

- Resistance to torsion during wrapping. Recommended minimum cross-sectional area is one half by two times diameter of wire.
- Adaptability to wrapping tool.
- Number of connections to be carried. Must be long enough to hold the one, two, or three connections.

Here are some typical cross-sectional dimensions for square and rectangular terminals for wire sizes 18 and smaller: 0.045 x 0.045 in., 0.031 x 0.062 in., and 0.030 x 0.050 in. Dimensions for larger size wires and other shapes are not firmly established and consequently subject to your own evaluation.

Lengths are a function of wire size and number of turns. Table I gives lengths for the square and rectangular terminals mentioned above, and terminal materials are listed in Table II.

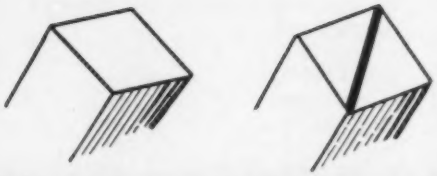
Terminal spacing

Distance between terminals depends on size of wire, size of terminal, number of wires running past a terminal, and clearance needed for the wrapping tool. Space must be provided not only for the total number of wires, but for clearance for the tool when several wires are already present. The tool manufacturer can tell you the spacing required after you supply details of your application. Then you can standardize on a suitable modular spacing. Terminals in the sizes given above have been spaced on 0.156, 0.200-, and 0.250-in. centers for both 24- and 26-gage wires. Here at Hughes we have standardized practically all equipment by using terminals that are 0.030 x 0.050 in. on 0.200-in. centers in a square matrix for 24-gage wire. We have used all tooling including the automatic machines.

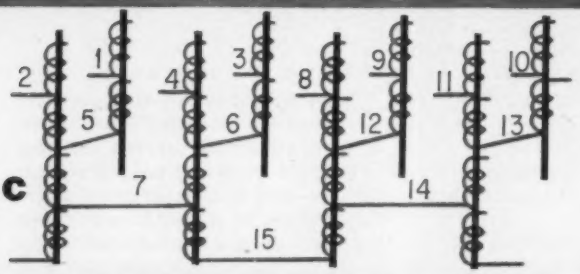
Hughes equipment uses two connections per terminal, with connection densities to about 40 per square in. Ten or more wires running through the channels produced by the terminals are common and require special operator technique to produce these high densities without damaging the wire insulation by the tools or the sharp edges of unused terminals.

Number of turns

The Bell System specifies a minimum of five turns for 22-gage wire and six turns for 24 gage. The number of turns selected provides enough contact area and mechanical strength.

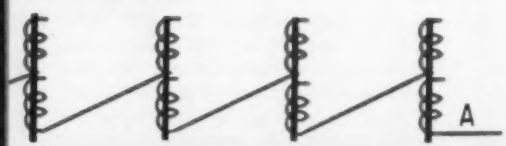


1 THESE TERMINAL SHAPES provide necessary "bite" for the turns of wire.



2 REPAIR BECOMES IMPRACTICAL when number of connections per terminal goes above three. In (A) two wires are removed to replace No. 2; in (B) six wires are removed to replace No. 7; in (C) 14 wires are removed to replace No. 15.

PROGRAM



3 IN THE CORRECT PROGRAM, only two wires must be removed to replace C. When incorrectly programmed, all wires in the chain must be removed to replace A.

Stationary equipment installations require turns of bare conductor only, but mobile and military applications demand half to one turn of insulated wire besides the turns of bare conductor because of vibration and shock resistance requirements. The insulation relieves the concentration of stress at the point where the wire first touches the terminal.

Number of connections

Because of the torsion applied during wrapping and because of possible repair or circuit changes, no more than three connections should be planned per terminal. For a given cross-sectional area, terminal length is limited by torsional resistance needed for the wrapping operation. Of course, you could increase cross-sectional area and thereby increase length to handle more connections, but would then lose the benefit of high joint density. Moreover, after three connections per terminal, repair or circuit changes become impractical if not impossible (Fig 2).

Programming the interconnections

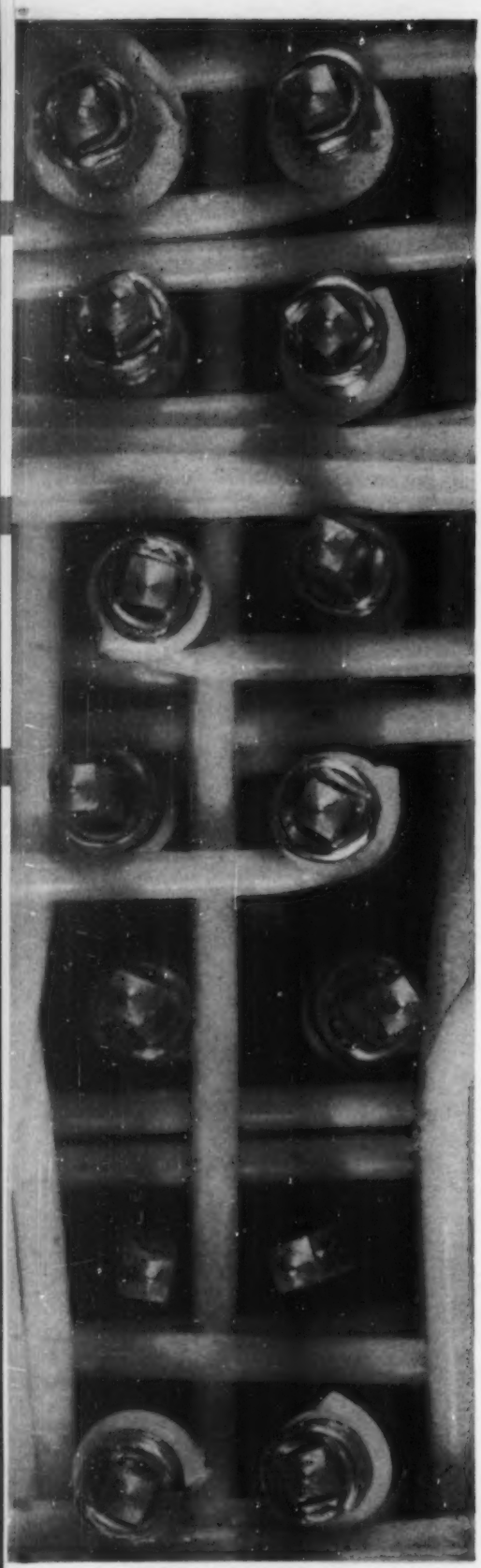
It pays to list the wire paths in sequence prior to wrapping, especially when the interconnection board must be tightly packed with wires. Here

table I . . SUGGESTED TERMINAL LENGTHS
(based on one turn more than minimum)

No. of connections	10 turns of 26-ga wire (in.)	7 turns of 24-ga wire (in.)	6 turns of 22-ga wire (in.)	6 turns of 20-ga wire (in.)	6 turns of 18-ga wire (in.)
1	0.272	0.266	0.281	0.299	0.312
2	0.529	0.517	0.547	0.585	0.700
3	0.785	0.768	0.813	0.870	1.043

table II . . TERMINAL MATERIALS, HARDNESS, AND FINISH

Material		ASTM	Alloy	Hardness (min)	Finish
brass	punched	B-36	6, 8	½ hard	(1) Electrotinned per MIL-T-10727 or punched from coated or solder-coated stock. Heavy tin dipping not acceptable. (2) Silver plate (0.0002 to 0.0003 in.) plus gold (0.000,003 in.)
	drawn wire	B-134	6	hard	
phosphor-bronze	punched	B-103	A, C	½ hard	
	drawn wire	B-159	A	hard	
copper-silicon	punched	B-97	A	½ hard	
	drawn wire	B-99	A	hard	
nickel-silver	punched	B-122	1, 4, 8	½ hard	None
	drawn wire	B-151	D	hard	
aluminum	punched	B-209	ZG62A	T6 temper	Conversion coat per MIL-E-5541



are some typical rules for programming wire paths. These rules are for 24-gage wires with 0.010-in. insulation and terminals spaced 0.200 in. center to center:

- Lay wires uniformly in channels, making right-angle turns rather than running diagonally between terminals.
- Limit to 12 the number of wires between four adjacent terminals. This can vary somewhat depending on their sequence and the extent to which wires take the same path.
- Connect both ends of wire on same level. If you connect one end to the lowest part of a terminal, connect the other end in the same position. This prevents the chain reaction shown in Fig 3.
- For better packing efficiency and for better vibration resistance in two-layer assemblies, wrap short lengths first on bottom layer, then progress to longer leads. For second layer reverse order, starting with longest wires. Resultant package ties vibration-sensitive long leads between short leads in a rigid mat.

Tools you need

Tools are available in various degrees of complexity (and cost). The volume of connection you wrap will determine how complex a tool you need. Here's what's available:

- Simple hand-twist tool that accepts prestripped wire.
- Pneumatic or electric hand gun that accepts prestripped wire and wraps when you squeeze the trigger.
- Power-driven tool that accepts prestripped wire and wraps by power-driven mechanisms.
- Combination tool that automatically cuts, strips, and wraps the wire by power drive.
- Programmed machine that automatically cuts, strips, and wraps an entire chassis by program tape or cards. It requires no operator time during wrapping. One such machine, costing $80,000, performs the complete operation for each wire in 7½ seconds.

How to test

There are two main ways of testing a wrapped connection: check the electrical properties or the mechanical properties; or, of course, check both.

The electrical test is merely a continuity check.

The mechanical properties are measured either by the force needed to strip the helix of wire from the terminal while maintaining the helix intact, or by the force needed to unwrap the wire from the terminal. Generally the stripping force is preferred. Typical values obtained with various wire sizes on square and rectangular terminals are these:

Wire size (gage)	Force, (lb)
14	25
16	20
18	15
20	9
22	9
24	7
26	6

Table III shows that stripping force is a function of material. The variation in stripping forces explains the need to establish your own requirements to get low electrical resistance for the combination of materials you choose. Only the minimum value is necessary, so the test method does not have to be destructive for process control. The test can establish only that the stripping force is greater than minimum.

Unwrapping the wire without measuring the force needed is also an acceptable control test. The wire must unwrap without breaking, which would mean the wire had received excessive work-hardening. (See Fig 4.)

Besides checking the connection to make sure it was correctly wrapped, be sure it will retain its stress. This is generally done when evaluating a new type of connection—new wire or terminal size or material—and usual procedure is first to subject the connection to an accelerated heat-aging, which produces stress relaxation; then to measure the stripping force. Accelerated heat-aging can be done in two or three hours at 347 F.

Both Bell and IBM find that for their purpose accelerated aging is better at lower temperatures for a longer time. One Bell test is conducted at 221 F for 150 days. Each week during the five months the connection is cooled to room temperature; every second week the resistance variation is measured while the connection is at room temperature. During the resistance test, the connection is mechanically plucked two or three times at an amplitude of $\frac{1}{32}$ in.

IBM's test continues for seven days. A daily cycle consists of four hours at 162 F with 95% relative humidity, four hours at room temperature, and 16 hours at 162 F with 60% relative humidity. The connection is mechanically plucked every two minutes for 5000 times at an amplitude of $\frac{1}{16}$ in.

After the wrapped connections are put into production, you might introduce a sampling plan of one specimen in ten. Once the tools and operators are proven, the sample can drop gradually to one in 100, one a day, one a

week, or some longer interval. The operator wraps a sample connection at the specified interval. The sample connection is not wrapped on the equipmen being wired. An inspector collects the samples and performs either the stripping-force or the unwrap test. Eventually this sampling plan can be dropped. Every connection, however, should be visually inspected, then checked for electrical continuity.

Here at Hughes we have standardized primarily on one conductor (tinned copper) and one terminal (0.030 x 0.050 in. gold-plated phosphor bronze) and have reduced inspection to visual, unwrap, and continuity tests except for new tooling, for periodic requalification of tooling, and when new sources of wire and terminals are introduced. Visual inspection (Fig 5) verifies:

- Deformation of both wire and terminal have occurred.
- Turns of conductor do not overlap.
- Turns are snug (gap between turns must not exceed ½ wire diameter).
- One turn of insulated conductor is wrapped for vibration resistance.
- End of last turn (tail) does not extend more than ½ wire diameter from terminal.

Unwrap tests verify mutual deformation of wire and terminal, and that excessive work-hardening has not occurred (if wire doesn't break).

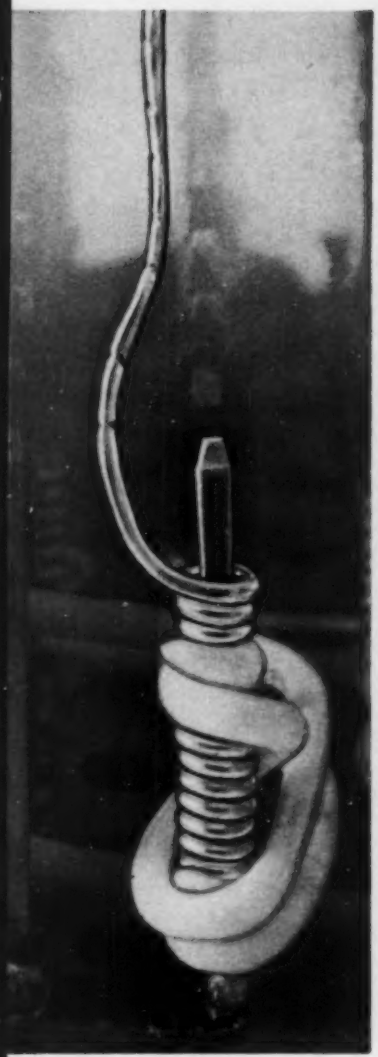
Electrical resistance verifies a gastight and conductive joint, although continuity tests are generally sufficient.

Electrical properties

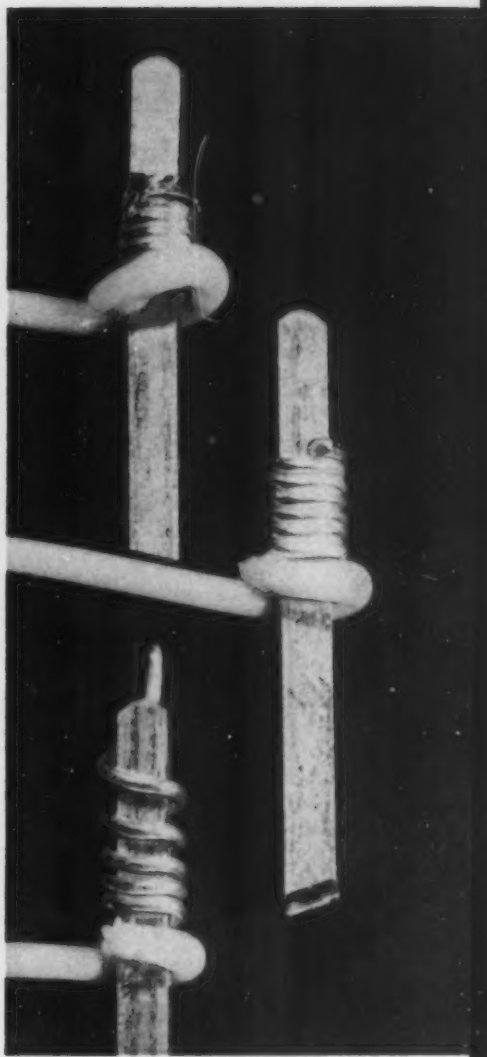
A connection consisting of five to six turns of tinned copper wrapped on a gold-plated phosphor bronze terminal has a nominal resistance of two milliohms when 2.3 amp dc is applied. Test results indicate that after full environmental exposure resistance should not increase more than one milliohm.

Because of the large contact area between wire and terminal, power handling capabilities of the connection can be based on the power capacity of the wire (as listed in standard temperature-rise tables). Extremely long service life can be assured if temperature in connection or wire is held to 212 F or lower. Temperatures between 212 F and 302 F might result in connection resistances of 100 milliohms or greater over a period of several years. Temperatures over 302 F require evaluation.

Ac losses in a wrapped connection increase as frequency increases; however, up to 60 megacycles the



4 UNWRAPPING WIRE is one test of mechanical strength. Here it shows the desired deformation. To unwrap, a pencil-like tool is placed over the end of the terminal and rotated. The connection can fail the test in two ways: if the wrap was too tight, the wire will break, indicating excessive work-hardening. If too loose, neither terminal nor wire will show sufficient deformation.



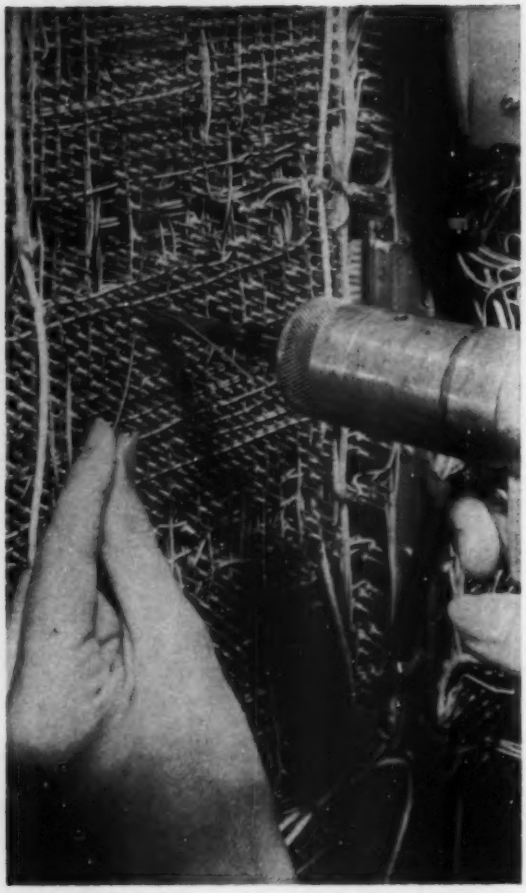
5 RIGHT AND WRONG WAYS to wrap connections. (Top): result of pressing hand gun too hard against terminal—the top turn overlaps. (Bottom): gun was pressed so loosely that it was being removed in act of wrapping—turns are too far apart. (Center): connection is correct. (In general, wrapping technique is so simple that, for these examples, operator found it difficult to produce the bad connections.)

table III . . RANGE OF STRIPPING FORCES FOR 24-GAGE WIRE

Terminal (0.031 x 0.062 in.)	Wire (24 gage)	Force Range, lb
tinned nickel silver	tinned copper	8-18
untinned brass (annealed)	tinned copper	15-24
untinned brass (¾ hard)	tinned copper	10-21
untinned nickel silver	tinned copper	5-15
tinned nickel silver	untinned copper	6-16

Equipment and Systems Div, Burroughs Corp

AUTOMATIC MACHINE operated from console cuts wire to length, strips the ends, and wraps 10,000 terminals on a back panel.



HAND GUN, fed pre-cut and pre-stripped wire, wraps terminals one at a time.

losses are about the same or lower than for soldered joints.

Environmental resistance

The wrapping operation produces a gas-tight area between wire and terminal. This tightness means the joint can withstand corrosive atmosphere with little, if any, changes in resistance. But continued exposure to an erosive environment will reduce the contact area and so, as the contact area falls below that of the cross-sectional area of the wire, the resistance will increase.

The action that produces the gas-tight contact area scrapes away tarnish so that low-resistance joints can be made with tarnished terminals. This effect makes possible rework on equipment which has been exposed to corrosive atmospheres.

Failure rates during vibration tests are lower for wrapped connections containing one turn of insulation than for soldered connections. This holds true up to about 90 hours of vibration at 55 cycles per second. Above 90 hours, failure rate of the wrapped connections exceeds that of soldered stranded wire, but is well below that of soldered solid wire.

When repairing

A pencil-like tool is used to unwrap a connection. When placed over the end of the terminal and rotated, it unwinds the helix of wire. The terminal is undamaged, and despite deformation caused by the wrap, it can be rewrapped 50 times or more. However, the wire must be replaced, or cut back to remove the used portion, because it will generally break if rewrapped.

EDITOR'S NOTE: For information on other types of electrical connections, see:

Choose the Right Electrical Connection, Dec 7 '59, p 71. Comprehensive survey of all known permanent and separable electrical connections, with an easy-to-use selection table based on performance.

Reliable Electrical Connections, Feb 2 '59, p 54. An on-the-spot report of an Electronic Industries Association Reliability symposium. Here, solder, crimp, weld and others are aired.

Soldered connections are comprehensively covered in three articles:

How to Design the Soldered Electrical Connection, June 12 '61, p 57. Author presents complete design procedure for all types of soldered connections. Included are tables covering comparison of soldered vs other electrical connectors, current-carrying capacity of insulated copper wire.

The Right Soft Solder, Mar 6 '61, p 39. Compares 28 different solders and discusses all important design criteria: matching solder to base metal, corrosion, strength, thermal expansion.

The Right Solder Flux, June 13 '60, p 43. Describes the mechanism of solder-joint formation in detail, so that a joint can be properly engineered and evaluated. Covered are general and special electrical-joint fluxes.

—Frank Hall

How to handle

Errors in measurements

They're unavoidable, no matter how precise or how accurate your instruments. But you can head off the troubles they cause by heeding these precautions.

ROBERT P BENEDICT, development engineer, Westinghouse Electric Corp

ONE of our earliest disappointments as engineering students, no doubt, was learning that nothing can be measured exactly. Even today, it may seem unforgivable that an "exact science" like engineering can't yield exact answers. Working with instruments whose readings are as much as 1 or 2% in error may seem to be flirting with danger. But there is little danger in these unavoidable errors. The real danger lies in failing to recognize that an error exists . . . or in allowing a presumably "precise" measurement to lull us into a false sense of security. To avoid these pitfalls we must develop a conscious awareness of experimental uncertainties, learn where to look for them and how to handle them.

Once we understand this basic principle—that no measurement is without error—we are faced immediately by three questions: (1) What is the best way to report uncertainties? (2) How will the error in the measurement be propagated into the result? (3) How can we specify a result that we can have confidence in. Let us take the questions one at a time.

How much plus and minus?

It is understood that in reporting a measurement we cannot simply report an absolute magnitude because this assumes there is no error. Traditionally, the margin for error is reported as a plus-or-minus value tacked onto the absolute value. But even this is not enough. We must recognize that the uncertainty interval itself is uncertain. When we report a reading of 10 ± ½ how certain are we that the true reading lies within that ±½ interval? This is why some experimenters suggest that each measurement be given in three parts—a magnitude, an uncertainty interval, and odds predicting the probability that the actual error lies within the chosen interval.

Suppose you read a temperature as 150.5 F. Based on past experience with this particular instrument and assuming certain experimental errors and reading errors (parallax, etc) you estimate this reading is correct within ±0.3. Therefore you record the reading as 150.5 ± 0.3 (5 to 1), meaning that if the temperature were measured repeatedly, you feel the true temperature would lie within the uncertainty interval 83% of the time. If you wish to indicate more confidence in your estimate of uncertainty, you can report the temperature as 150.5 ± 0.3 (19 to 1)—indicating that the true temperature has a 95% chance of falling within the uncertainty interval.

Of course, when there are actually a large number of repeated measurements instead of just one, you can be more exact about the interval and the odds. Assuming a normal statistical distribution, you could compute standard deviation $\sigma = \sqrt{(\Sigma x^2 - \bar{x}\,\Sigma x)/n}$ and pick the interval corresponding to the odds you need. For example, odds of 19 to 1 correspond to an interval of $\pm 2\sigma$, and assuming $\sigma = 0.015$ you could report a temperature of 150.5 ± 0.03 (19 to 1) with considerable confidence.

The uncertainty interval can also be expressed in relative terms. For example, the same temperature could be reported as 150.5 ± 0.2%. Relative uncertainties are sometimes more convenient to manipulate than are the absolute uncertainties.

How far wrong?

Now we are ready to consider the second question: What effect do these uncertainties have on the results? We recall two general mathematical rules.

1. The absolute uncertainty of a sum or difference is not greater than the sum of absolute uncertainties of the terms.
2. The relative uncertainty of a product or quotient is not greater than the sum of relative uncertainties of the factors.

While these rules are sufficient for manipulating the uncertainties in some simple equations, a root-square summation has been found to be more realistic. If, for example, a result R is related to variables V by the following equation

$$R = K V_1^A V_2^B V_3^C$$

then, according to rule 2, the relative uncertainty of the result is

$$\frac{\epsilon_R}{R} = \frac{A\,\epsilon_1}{V_1} + \frac{B\,\epsilon_2}{V_2} + \frac{C\,\epsilon_3}{V_3}$$

where the ϵ's are absolute uncertainties. In the root-square form, the relative uncertainty is

$$\frac{\epsilon_R}{R} = \text{rss}\sqrt{\frac{(A\,\epsilon_1)^2}{V_1} + \frac{(B\,\epsilon_2)^2}{V_2} + \frac{(C\,\epsilon_3)^2}{V_3}}$$

This is a more realistic expression and is recommended for predicting results based on a number of independent variables.

Example: Suppose it is necessary to measure the airflow through a system to within ± 2.5%, for results that are new and meaningful. Before you begin an expensive test, first make an uncertainty analysis to discover whether your proposed instrument and methods offer a fair chance of obtain-

ing the goal. To measure flow, you have chosen an ASME long-radius nozzle having the following characteristic equation

$$W/\Delta t = 1.86 \sqrt{p\Delta p/T}$$

where

$W/\Delta t$ = airflow, lb/sec
p = pressure upstream of nozzle throat, in. Hg
Δp = pressure difference across nozzle, in. H_2O
T = temperature upstream of nozzle throat, °R

Listing the range of the variables and the expected uncertainties for each gives the following table

Variable	Range of variable	Expected uncertainty	Odds
p	30 to 35	±0.1	20 to 1
Δp	2 to 10	±0.2	20 to 1
T	510 to 610	±2	20 to 1

Notice that uncertainties have been chosen with odds that allow only a small chance for the true value to fall outside this interval.

Using the minimum value for each variable (to give maximum relative uncertainty) and substituting into the root-square equation gives

$$\frac{\epsilon_R}{W/\Delta t} = \pm\sqrt{\left(\tfrac{1}{2}\times\frac{0.1}{30}\right)^2+\left(\tfrac{1}{2}\times\frac{0.2}{2}\right)^2+\left(\tfrac{1}{2}\times\frac{2}{510}\right)^2}$$
$$= \pm\tfrac{1}{2}\sqrt{(11+10{,}000+15)\,10^{-4}}$$
$$= \pm 5\%\ (20\text{ to }1)$$

From this analysis there is obviously little chance of determining airflow to within ± 2.5% with these measuring uncertainties. It is also clear that the only measurement having a significant effect on the airflow is the pressure difference across the nozzle.

Suppose you can reduce the uncertainty in Δp to ± 0.1 in. Hg by a suitable change in instrumentation or method. Then the uncertainty in airflow would be reduced to $\epsilon_R/(W/\Delta t) = \pm$ 2.5% (20 to 1). With this one change, the experiment should now be a success.

For best results

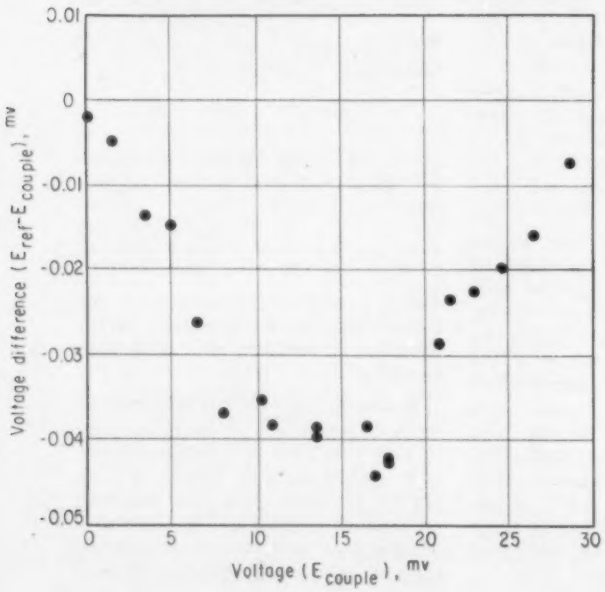
We now come to the third question. How can we convert uncertain results into a meaningful test interpretation? Stated another way, the problem is really one of finding the curve that most accurately represents the form of our scattered data.

Actually, a precise relation characterizing a single set of experimental points is indeterminate. Each point has its own halo of uncertainty. Simply connecting points with straight lines exaggerates the effect of a poor test-point and presents an unrealistic picture of natural events. Passing a smooth curve through the data may call attention to our individual artistic abilities but it will fail to provide an accurate representation of the situation. We are left with only one alternative: analysis of the data that results in a curve satisfying proven statistical tests.

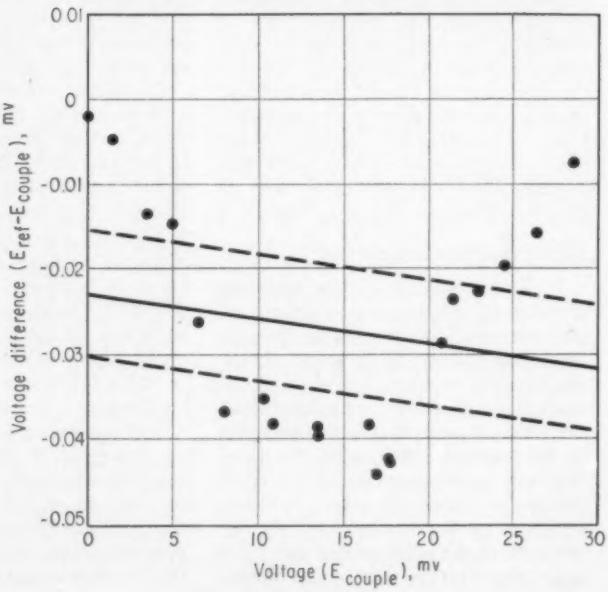
Surely the curve that gives "best fit" must agree with the experimental evidence. The best measure of this is to make certain that all data points fall within the uncertainty envelope surrounding the curve. The limits of this envelope can be determined two

Example . . . calibrating

SCATTERED DATA
from a thermocouple calibration demonstrate the capriciousness of experimental errors. Undoubtedly there is a smooth curve, but what shape?



FIRST-DEGREE
interpretation of data is clearly unsatisfactory. Boundaries of uncertainty envelope were based on previous experience with similar instruments.



ways. If the same measurements are repeated several times during the course of the experiment, the maximum spread between points can be taken as the uncertainty interval. In most experiments, however, we do not have a sufficient number of repeated measurements to establish the envelope this way. In these instances, we must rely on experience or references in the literature.

Once the envelope is determined, the next step is to find the curve whose envelope encloses all data points. The usual way is to find the least-squares interpolation equation that gives the best fit. (For a complete description of this method, see "Regression Analysis Digs Out Equations from Scattered Data," July 20 '59, p 62). The required equation (and curve) is the lowest degree equation whose envelope encloses all data points. To avoid errors in experiments where there is only a small number of data points, it has been found that the number of experimental points should be at least two times one more than the degree of the chosen interpolation equation. If, for example, a fourth-degree equation is found to give best fit, there should be at least $2(4 + 1) = 10$ data points.

Example: You wish to calibrate a thermocouple by preparing a graph that shows the correction to apply for any given voltage output. You begin by making 20 readings in random order, over a wide range of known standard temperatures and recording the voltage and temperature for each. These are compared with a table of reference voltage and the difference between your readings and standard readings are recorded. Plot voltage differences against thermocouple voltage as shown in the graph at left, below.

Because there are no repeated measurements, the uncertainty interval will have to be determined by experience. Based on previous experiments, you conclude that a reasonable interval is $\pm$ 0.0075. Now, starting with a first-degree, least-squares, interpolation equation, find the equation and draw the line representing it along with its uncertainty envelope. As is evident in the second graph, this is a poor fit for the plotted data (of course, a brief examination of the data would have indicated this). The second-degree equation comes closer, but still leaves one point outside the envelope. The third-degree equation (lower right) is clearly the answer.

Now check to be certain there are enough data to support the third-degree equation. The empirical test says there should be at least $2(3 + 1) = 8$ points, a condition easily met. Based on the uncertainty envelope, corrected readings made with this curve and thermocouple should give measurements within 0.0075 mv.

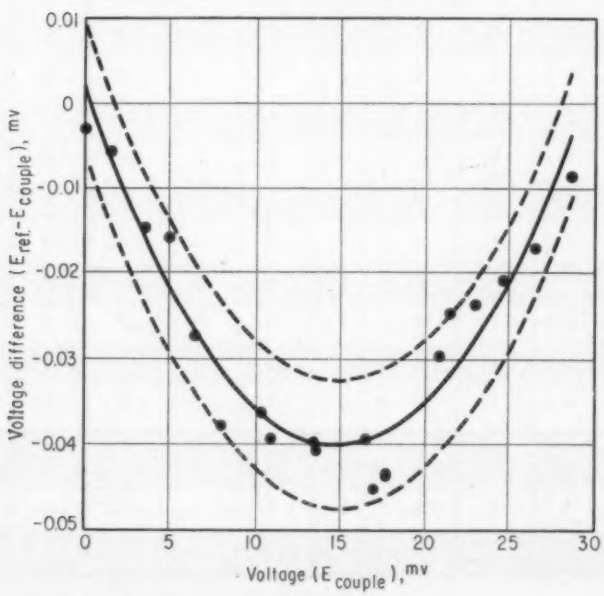
EDITOR'S NOTE: For more about the statistical tools of testing, see:

Ready-Made Design Simplifies Multi-variable Experiments, Dec 21 '59, p 56—With this chart you can set up an experiment that gives maximum information from minimum number of tests.

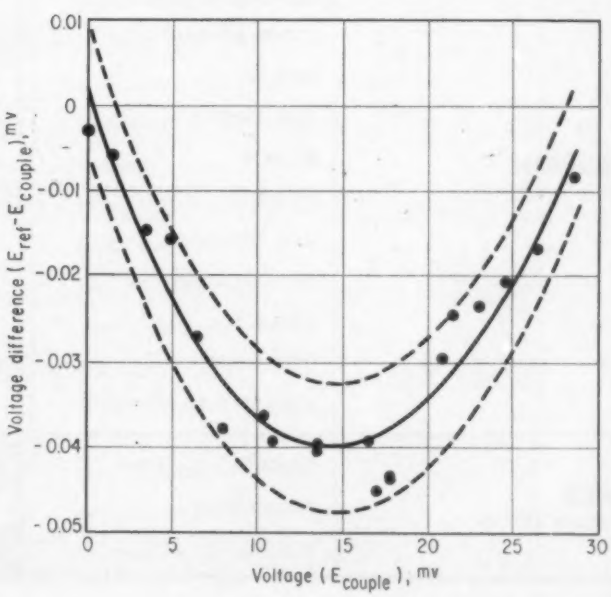
—Charles J Lynch

a thermocouple

SECOND-DEGREE
interpolation equation gives curve which comes closer to representing the data, but one point still lies outside the uncertainty envelope.



THIRD-DEGREE
equation gives best fit. With this curve, thermocouple readings can be corrected to give true readings within $\pm$0.0075 mv (or approx ¼ deg F).



For best results when you specify a

Coating on iron castings

It's not just a matter of selecting the appropriate resin properties. The casting shape must be designed to eliminate coating troubles.

S S GREENE, technical editor, Gray Iron Founders Society

How organic coatings compare

E=excellent G=good F=fair P=poor

RELATIVE COST	RESIN	RESISTANCE TO CHEMICALS AND ENVIRONMENT								
		HYDROCARBONS	SOLVENTS	ACIDS	ALKALIS	SALTS	WATER	WEATHERING	HEAT	COLD
LOW (less than 2¢/sqft/mil)	PHENOLIC	E	E	E	F	E	E	E	G	E
	UREA	E	G	E	E	E	G	G	G	G
	POLYESTER	G	G	G	F	E	G	G	G	G
	ALKYD	G	P	F	F	E	G	E	F	G
MODERATE (2 to 5¢/sqft/mil)	EPOXY	E	E	E	E	E	G	G	E	E
	POLYETHYLENE	G	E	E	E	E	E	G	F	E
	STYRENE-BUTADIENE	E	G	E	E	E	E	G	G	E
	URETHANE	G	E	G	G	E	E	E	E	G
	VINYL CHLORIDE	G	F	E	E	E	E	E	G	G
	MELAMINE	E	G	E	E	E	G	E	G	G
	POLYAMIDE	F	G	F	E	E	F	P	G	G
	VINYL BUTYRAL	G	F	F	G	G	G	E	G	E
	CELLULOSE NITRATE	F	F	G	F	E	E	E	P	G
	ACRYLIC	F	P	F	G	E	E	E	P	F
	VINYL ACETATE	F	P	F	F	F	G	E	F	F
	CELLULOSE ACETATE BUTYRATE	F	F	F	F	G	F	E	P	G
HIGH (over 5¢/sqft/mil)	CHLORINATED POLYETHER	G	E	E	E	E	E	E	G	E
	FLUOROCARBON	E	E	E	E	E	E	E	E	G
	SILICONE	G	F	G	G	G	E	E	E	E

GRAY cast irons are more resistant to most types of corrosion than are the carbon or low-alloy steels. This is because the graphite flakes in gray iron tend to bind the rust into a thick film that offers some protection. But the rusted appearance is a drawback in most applications, explaining why protectives such as paints and other organic coatings are usually specified. In fact, the finished appearance of the product becomes as important as its mechanical performance, and design must therefore consider castings for their coating properties. A cheaper coating may prove more expensive in the long run if it doesn't coat properly.

These rules will help:

- Shape the castings for progressive solidification—minimizing hot spots will cut down the localized porosity that causes most coating problems.
- Enlarge all radii and fillets to at least ⅛ in.—sharp edges and corners are difficult to cover, especially by spraying; also, coatings wear more quickly at sharp edges.
- Keep surfaces accessible so they can be readily cleaned—pockets and undercuts are difficult to clean thoroughly and coatings may not adhere at these points.
- Review the drawing to eliminate all unnecessary protuberances such as small ribs and ridges—coatings may run off such areas before they build up the desired thickness.
- Specify a stress-relief heat treatment prior to coating—this is to minimize tendency of the less-resilient coatings to craze or crack.
- Visualize the process and specify noncritical points where the part can be held or suspended while coating.
- Add vent or drain holes to avoid trapping pockets of air or paint. These holes can improve the casting because they eliminate hot spots at intersections of ribs and gussets. Or, added at a later stage, they can help redistribute stresses in the casting. (For details on how to redistribute metal in a casting to reduce maximum stresses see: "New Techniques for Photoelastic Coatings," July 24, p 42).

Porosity causes poor coating

Cast irons are not inherently porous, although the cheapest varieties, such as used for window-sash counterweights, are known for this drawback. Actually, gray cast irons are more castable than the nonferrous metals. This is because they can be cast into complex shapes without porosity trouble. In contrast, such metals as

for gray iron castings

	EASE OF APPLICATION						TYPICAL APPLICATIONS
				PROCESS			
ABRASION	NEED FOR PRIMER	AIR-DRY	BAKE OR CURE	SPRAY	DIP	FLUIDIZED BED	
E	no	√	√	√	√	–	appliances
E	no	–	√	√	√	–	appliances
G	no	√	√	√	√	–	thick coatings
G	yes	√	√	√	√	–	general purpose
E	no	√	√	√	√	√	scratch resistant finish
F	no	–	√	–	–	√	resilient impact-resistant coatings
G	no	√	√	√	√	–	general purpose
G	yes	√	√	√	√	–	scuff-resistant coatings, chemical and marine finishes
E	yes	√	√	√	√	√	chemical equipment
E	no	–	√	√	√	–	appliances
E	no	√	√	√	√	√	abrasion resistant coatings
E	no	√	√	√	√	–	general purpose, primers
F	yes	√	√	√	√	–	high gloss lacquer
F	yes	√	√	√	√	–	water resistant finishes
E	no	√	√	√	√	–	decorative
F	yes	√	√	√	√	–	decorative
F	no	–	√	–	–	√	chemical equipment
P	yes	–	√	√	–	√	chemical equipment, non-stick surfaces
G	yes	√	√	√	√	–	heat-resistant finishes

aluminum are difficult to cast in the same shape with the same soundness.

Although the production of sound castings is largely the responsibility of the foundry, proper design of the part will help. Usually the more castable shapes will have more consistent strength and better soundness along with less porosity.

In addition, the lower-strength cast irons are easier to cast. It is generally more difficult to completely eliminate porosity from the higher-strength irons such as Classes 40, 50, and 60. This tendency, while not apparent in simple shapes, becomes serious when a high-strength iron is specified for complex shapes. Localized porosity can occur in isolated thick sections because they freeze last. For example, an adjoining section with a thickness change over 4 to 1 can cause trouble although the better foundries will successfully cast ratios as high as 10 to 1.

Although close limitations on metal composition should not be used for gray iron, certain chemical elements are often associated with porosity. For example, internal porosity may appear when the phosphoros content exceeds 0.25%. For complex castings, 0.20% usually is a practical maximum, and some foundries prefer less than 0.10%. Chromium and molybdenum accentuate the effect of phosphoros, while nickel offsets its effect. Generally, castings should have sufficient manganese; but excess sulfur increases porosity.

After machining, if a casting does not coat properly because of its porosity, the part can be salvaged by filling the pores and adding a coating of the air-drying type.

Such impregnation is standard procedure for some nonferrous castings but it should be considered only a stopgap measure for cast irons—the added expense can exceed initial cost of the casting. Among impregnating materials, those preferred are the thermosetting resins such as the phenolics. After they have cured, the casting can then be coated by any organic resin.

A cheaper alternative is to fill the pores with a brushed or troweled plastic and follow this with a compatible air-drying primer and coating. Baked or fused coatings cannot be used here because air trapped in the pores will expand and blister the coating.

The coating process

No casting is too large or too intricate to be coated. However, size and shape will determine the choice of coating method and this, in turn, may narrow the choice of coating materials.

Spraying is generally favored for castings with simple shapes and also those too large to be dipped. Surfaces must be accessible—it is almost impossible to spray-coat sharp edges, and the process tends to fill the bottoms of deep holes and grooves without coating the sides. Internal surfaces can be coated with special equipment but the part must have openings large enough to take the inserted nozzles. In general, spray guns that carry the paint with compressed air waste 10% or more by overspray. Giving the part an electrostatic change and the paint an opposite charge will attract the paint to the part and eliminate such waste.

Dipping is an economical way to coat intricate castings, especially if they have narrow, deep grooves or small holes, but the part must drain properly. Paint will drain away from the point of suspension and form a bead or drip at the lowest edge. This bead should be kept off mating edges, where it would interfere with fit; and away from surfaces, where it would detract from appearance of the part.

Fluidized-bed method gives uniform coverage on complex shapes with sharp edges and undercuts. The coatings that result are free from tears, runs, and drips, and do not bridge over openings. The procedure is to lower heated castings into a bed of resin powder which is fluidized (that is, suspended by a rising current of air). The part with its adhering powder is then reheated. This fuses the powder into a continuous coat. Coating thickness can be controlled from a few mils to over 50 mils.

Selecting the coating

The type of organic coating will be determined by the end use of the casting. For example, on machine-tool housings, coatings should have good abrasion resistance and withstand grease and cutting oil; on laboratory equipment, the finish should have good resistance to chemicals and abrasion; on food and hospital equipment, coatings must be nontoxic and withstand cleaning agents and boiling water. If castings are used at elevated temperatures, the coatings should not craze when the casting expands. At the other extreme, the more brittle coatings should be avoided because they tend to crack at low temperatures.

The table on page 96 is divided into three price ranges, with the least expensive listed at the top. Within each group, resins are graded for their durability, according to number of "excellent" ratings received in resistance to environments. Once you establish the conditions that the coatings must meet, it is simple to select the coating resin. Here, being realistic and limiting the number of requirements will improve your chances of finding a low-cost coating to fill your needs. In general, the phenolics and alkyds are popular because they meet most requirements for appliances and other indoor applications.

If the resin requires a primer, the casting must be first undercoated with a different resin. Baking resins are usually preferred for this purpose to shorten the processing time between coats. Finished coats that are baked or oven-dried are also preferred because they are harder, and quickly build up maximum corrosion resistance. The enamels or cured coatings in baked form generally have better resistance to environments than in unbaked form.

For coating intricate shapes, only a limited number of resins can be adapted to fluidized-bed application. While this method is comparatively recent, it is gaining wider use because it is a cheaper way to build up thick coatings than by spraying or dipping. At the same time these fused-on coatings retain many of the original resin properties because they are not dissolved in solvents. The heavy coatings of polyethylene, vinyl, nylon or fluorocarbon are resilient, resistant to scuffing and cuts, and can absorb mechanical impact. They are recommended for parts on racks and other handling equipment where mechanical contact cannot be avoided.

A good practice, to ensure castings that coat properly, is to spell out coating requirements on the blueprint. Additional precautions include inspecting the initial samples for penetration (using Magnaflux or dye) and testing them by coating in a production setup.

EDITOR'S NOTE: Other articles that give more details on the coatings described above, and other metal finishes:

A Fresh Look at Functional Finishes for Metals, July 17 '61, p 39—Comprehensive report on all the functional-finish systems. Compares properties, methods of application, costs—and tells how to specify them.

Which Vinyl Coating Process for Metal Parts? July 6 '59, p 70—How to choose from the 4 basic methods for applying thick vinyl films.

Hot-dipped Aluminum Coatings, Oct 28 '57, p 57—How the process allows you to substitute less-costly materials and reduce maintenance costs of finished parts. —*Herbert Kee*

New test data on

Aluminum screw strength

Breaking torque is lower than that of other metals—but a lower elastic modulus makes for much higher clamping forces.

W J DEWALT Alcoa Research Laboratories, Aluminum Company of America, New Kensington, Pa

ADVANTAGES OF aluminum threaded fasteners include: high clamping force to torque ratios, light weight, availability of anodized colors and freedom from corrosion. But choosing a fastener for a particular application doesn't end with selection of a material. Size, strength, head and thread style are equally important and, to add to the difficulty, interdependent.

Types of threaded fasteners in aluminum are similar to those found in other metals—bolts, machine screws, wood screws, sheetmetal screws, and the usual variety of nuts. Special types include thumb screws, bookbinding screws and nuts.

Holding power required and joint strength are among the important factors that dictate choice among types. Machine screws are stronger and offer more holding power than sheetmetal or wood screws; they also have better resistance to vibration, and may be assembled and disassembled frequently without loss in holding power. On the other hand, sheetmetal and wood screws are essential for blind assemblies, and their self-tapping characteristics make them more economical.

Choice of head style depends on torque, space, holding power and hardness of other assembly parts. When only nominal end pressure and torque are required to drive a screw, standard slotted screws will serve the purpose. When assembly space is limited, cross-recessed screws are more easily handled and perhaps more decorative.

When soft materials are being fastened, the larger bearing area of truss and pan heads is desirable. The larger head diameter requires somewhat less effort to develop the full torque

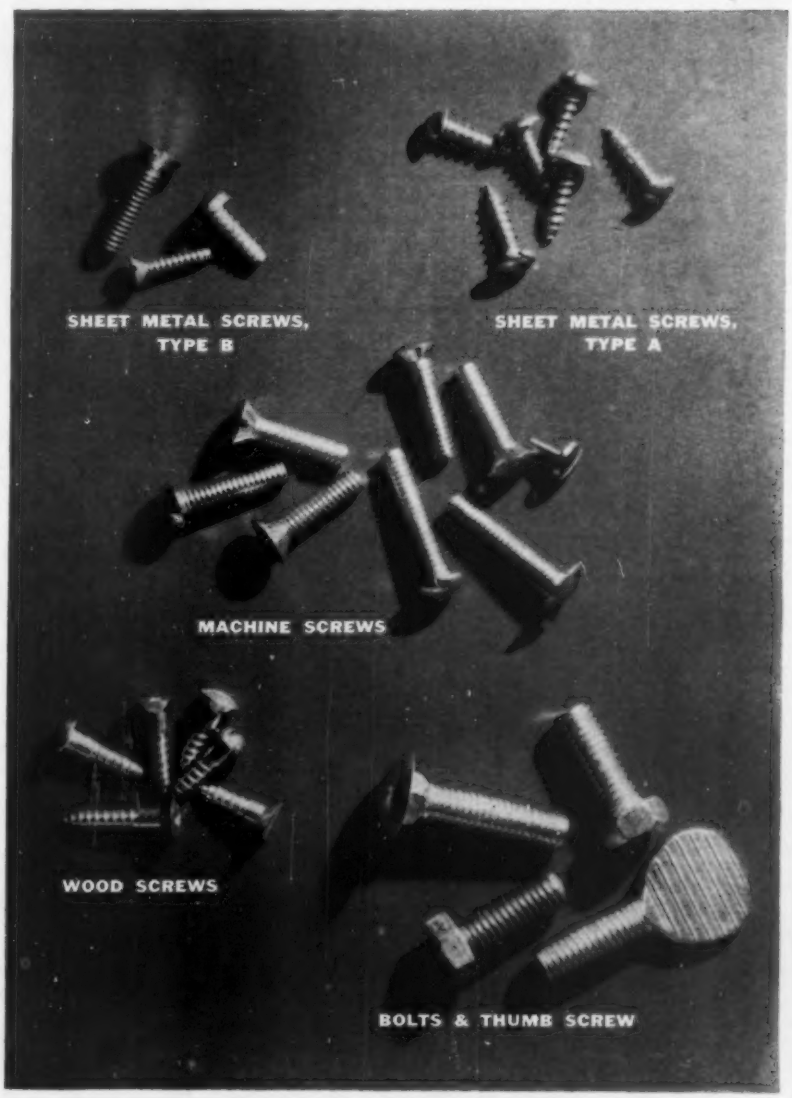


TABLE I Comparison of breaking torque values, in.-lb

BOLT SIZE NO.	ALUMINUM #2024-T4	BRASS	STAINLESS STEEL	
			#430	#304
6-32	10.5	11	15.2	19.5
8-32	19	21	25.7	45
10-24	27	35	45	65
¼-20	70	76	101	133

TABLE II Recommended drill sizes

SCREW SIZE NO.	SPRUCE 70% HOLE SIZE DRILL NO.	YELLOW OAK MEDIUM HARD 75% HOLE SIZE DRILL NO.	BIRCH—HARD MAPLE—VERY HARD 80% HOLE SIZE DRILL NO.
4	48	45	43
5	44	42	39
6	41	37	35
7	37	34	31
8	33	31	30
9	⅛	29	28
10	29	28	24
12	24	20	17
14	18	15	10
16	12	7	3

TABLE IV Tensile test results on 2024-T4 bolts and stock materials

BOLT SIZE NO.	BOLT ROOT AREA SQ IN.	NO. OF BOLTS TESTED	AVE BOLT TENSILE STRENGTH PSI	AVE STOCK TENSILE STRENGTH PSI	RATIO OF STRENGTHS
6-32	0.0078	140	75,400	68,900	1.09
8-32	0.0124	181	72,600	68,900	1.06
10-24	0.0152	239	72,600	69,000	1.05
10-32	0.0181	279	71,000	68,700	1.03
¼-20	0.028	638	73,800	68,800	1.07
5/16-18	0.047	234	70,100	69,100	1.02
⅜-16	0.070	161	69,900	69,100	1.01
½-13	0.129	205	69,000	68,900	1.00
⅝-11	0.207	101	67,300	69,200	0.97
¾-10	0.309	16	67,100	68,600	0.98

strength of the screw. However, this type doesn't work as well when eccentric loading may tend to force the thin head off its seat. Matching aluminum washers can also distribute bearing load of standard round heads on soft base materials.

For decorative purposes truss, flat, or oval-head screws with anodized finishes are effective.

Hexagon- or square-head screws are easier to wrench to full torque, particularly with larger sizes, although slotted-head screws are available up to ⅜ in. dia.

Torque limitations are important in aluminum threaded fasteners. Tests show that while the breaking torque for aluminum fasteners is lower than for other metals (Table I), the clamping force in many cases is much higher. For example, tests on ¼-in. aluminum bolts with an assembly torque of 30 in.-lb produced a clamping force of 1000 lb, but only 800 lb with stainless steel. At 50 in.-lb. torque, clamping force of aluminum was 1610 lb; of stainless steel, 1340 lb. On ⅜-in. bolts the same clamping load required 250-275 in.-lb torque with stainless steel and only 135-145 in.-lb with aluminum.

This shows that assembly torque with aluminum fasteners should be carefully controlled for maximum advantage. Commercial torque drivers of many types are available, and should be used in all assemblyline operations. For individual or occasional installation, torque can be gaged approximately by the number of turns required after preliminary tightening by hand.

In setting up procedures for the assembly of bolted joints, the following factors affecting torque must be considered: lubrication of the threads, use of a washer, freedom of thread fits, presence of foreign matter, and the smoothness of the surfaces on which nuts, washers and bolt heads rest. For this reason it is recommended that on assemblyline applications several bolts be stressed on failure in torque, and a final assembly practice of 70% or 80% of the minimum breaking torque specified.

Wood screw torque is proportional to the length of the screw and to the hardness of the wood. Various methods are used to reduce assembly torque, ie soap, grease and predrilled holes. Predrilling is recommended to keep the wood from splitting. Hole sizes in Table II are recommended. The clearance hole is not essential with short screws in soft woods and if they are not too close to the edge.

text continued, page 102

TABLE III Recommended hole sizes for 2024-T4 sheetmetal screws

In Alloys 1100, 3003, 5052 (All Tempers) and 6061-T4

TYPE A — GIMLET POINT

SCREW SIZE	METAL THICKNESS	PIERCED HOLE	DRILLED OR CLEAN PUNCHED HOLE	DRILL NUMBER
4	0.016	0.088	0.073	49
	0.020	0.088	0.073	49
	0.025	0.088	0.073	49
	0.032	0.098	0.076	48
6	0.016	0.098	0.082	45
	0.020	0.098	0.082	45
	0.025	0.098	0.082	45
	0.032	0.098	0.089	43
7	0.016	0.111	0.093	42
	0.020	0.111	0.093	42
	0.025	0.111	0.093	42
	0.032	0.111	0.093	40
	0.040	0.120	0.106	36
8	0.016	0.120	0.098	40
	0.020	0.120	0.098	40
	0.025	0.120	0.098	40
	0.032	0.120	0.104	37
	0.040	0.136	0.110	35
10	0.016	0.120	0.101	38
	0.020	0.120	0.101	38
	0.025	0.120	0.101	38
	0.032	0.136	0.106	36
	0.040	0.136	0.113	33
12	0.025	0.157	0.128	30
	0.032	0.157	0.136	29
	0.040	0.185	0.144	27
14	0.032	0.185	0.152	24
	0.040	0.185	0.166	19

TYPE B — BLUNT POINT (ALSO KNOWN AS TYPE Z)

SCREW SIZE	METAL THICKNESS	PIERCED HOLE	DRILLED OR CLEAN PUNCHED HOLE	DRILL NUMBER
4	0.025	0.086		
	0.032	0.086	0.086	44
	0.040	0.086	0.086	44
	0.051	0.086	0.086	44
	0.064		0.089	43
	0.081		0.089	43
	0.102		0.093	42
6	0.025	0.111		
	0.032	0.111	0.104	37
	0.040	0.111	0.104	37
	0.051	0.111	0.104	37
	0.064		0.106	36
	0.081		0.110	35
	0.102		0.110	35
7	0.025	0.120		
	0.032	0.120	0.113	33
	0.040	0.120	0.113	33
	0.051	0.120	0.116	32
	0.064		0.120	31
	0.081		0.128	30
	0.102		0.136	29
	0.125		0.136	29
8	0.025	0.136		
	0.032	0.136	0.116	32
	0.040	0.136	0.120	31
	0.051	0.136	0.128	30
	0.064		0.136	29
	0.081		0.140	28
8	0.102		0.147	26
	0.125		0.147	26
	0.156		0.149	25
	0.188		0.152	24
10	0.025	0.157		
	0.032	0.157		
	0.040	0.157	0.144	27
	0.051	0.157	0.144	27
	0.064		0.144	27
	0.081		0.147	26
	0.102		0.147	26
	0.125		0.154	23
	0.156		0.159	21
	0.188		0.166	19
12	0.051		0.161	20
	0.064		0.166	19
	0.081		0.173	17
	0.102		0.180	15
	0.125		0.182	14
	0.156		0.189	12
	0.188		0.189	12
	0.250		0.196	9
14	0.064		0.199	8
	0.081		0.201	7
	0.102		0.204	6
	0.125		0.209	4
	0.156		0.213	3
	0.188		0.213	3
	0.250		0.228	1

Sheetmetal screws available in two sizes—Type A with gimlet point, and Type B with a blunt point. They both have 60° V-shaped threads with sharp crests and wide roots similar to wood screw threads, though Type B has a slightly finer thread. Actually, they are internal thread-rolling tools made from high-strength 2024 alloy, heat-treated to insure high strength and hardness. Such screws will easily form threads in: all nonheat-treatable aluminum alloys of all tempers, heat-treatable extrusion alloy 6063 of all tempers, 6061-T4 alloy, certain casting alloys, wood, compositions and some plastics. Casting alloys containing silicon as a principal alloy and wrought alloys harder than 6061-T4 generally are either too abrasive, or will not flow properly to form a thread with a sheetmetal screw. Type B screws are generally used for thicker material, especially in the larger sizes, because the finer-pitch threads provide more engagement and holding power than Type A screws. In thinner materials and small lead-hole sizes the Type A screw is preferred.

Size of sheetmetal screw depends upon joint strength and "drivability" of the screw. Necessary driving torque must be lower than the torque strength of the screw, and this requires careful choice of lead-hole size. Tests indicate optimum size lead holes (see Table III) for average driving conditions, but they cannot be valid for all possible driving conditions. For example, if a screw is to be driven into light-gage annealed material, a smaller hole size might be advisable for better holding power. On the other hand, a larger-than-normal hole would make for easier driving in a heavy section of one of the harder alloys. There is a considerable spread between the necessary driving torque and the breaking torque of large screws. On smaller screws this spread decreases, and careful adjustment of power driving equipment is necessary.

Tensile strength of aluminum bolts and screws compares favorably with that of mild steel; in fact, the typical ultimate strength of 2024-T4 is nearly the same—68 ksi. However, when torque is applied, an aluminum fastener will undergo less rotation to failure after the yield point is reached than an equivalent mild steel fastener. This does not necessarily mean the steel fastener has greater over-all strength, but does point out the desirability of controlling the torque for maximum use of available strength.

For design purposes we have found it more accurate to use the minor diameter of the thread in calculating the strength of the screw. This is somewhat different from the usual calculation which is based on the average of the pitch and minor diameters. Table IV shows that average bolt tensile strength compares favorably with the average stock tensile strength.

These tests were made in a test fixture, Fig 1, and the results are well above calculated minimum values. When the results are plotted against the ratio of root area to gross area, Fig 2, the strength ratios are above unity for bolts and screws $\frac{5}{16}$-18 and smaller, but they drop slightly below unity for bolts up to one inch size. The screw and bolt tension test results are compared in Fig 2 with similar data obtained from round specimens having sharp 60° V-notches.

Another series of tests was made to test head quality and ductility of bolts with a 10° wedge under bolt head, Fig 1. There were no failures at the heads, and tensile strength loss caused by the 10° wedge did not exceed 7% for 2024-T4 bolts.

Shear strength and its relation to ultimate torque is important, because torque needs to be controlled to give maximum clamping load without shearing. Test results, Fig 3, show that this relationship can be expressed by the empirical formula:

$$T = \pi f_s d^3 k$$

Where T is the ultimate torque, in.-lb;

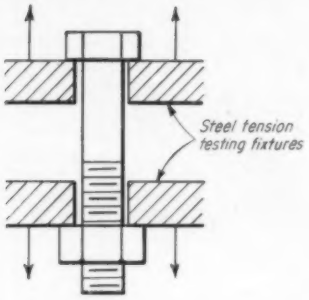
1 TEST SETUPS include simple tension fixtures (left), standard ASTM A370-54T 10° wedge for the bolt head test (center), and calibrated wrenches and load cylinder, with a vise for torque-clamping load tests (right).

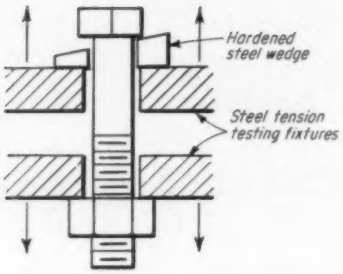
2 RATIO OF BOLT TENSILE STRENGTH to stock material tensile strength plotted against the ratio of root area to gross area shows values above unity for the smaller diameter bolts.

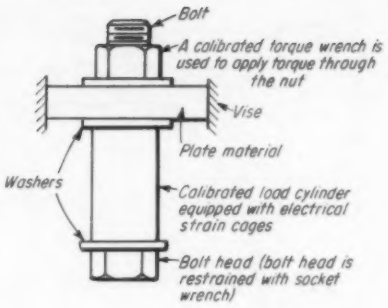
3 OPTIMUM TORQUE VALUES fall between two empirical curves. Points in the area to left of the upper curve will not produce maximum possible clamping loads; points right of the lower curve will exceed material shear strength.

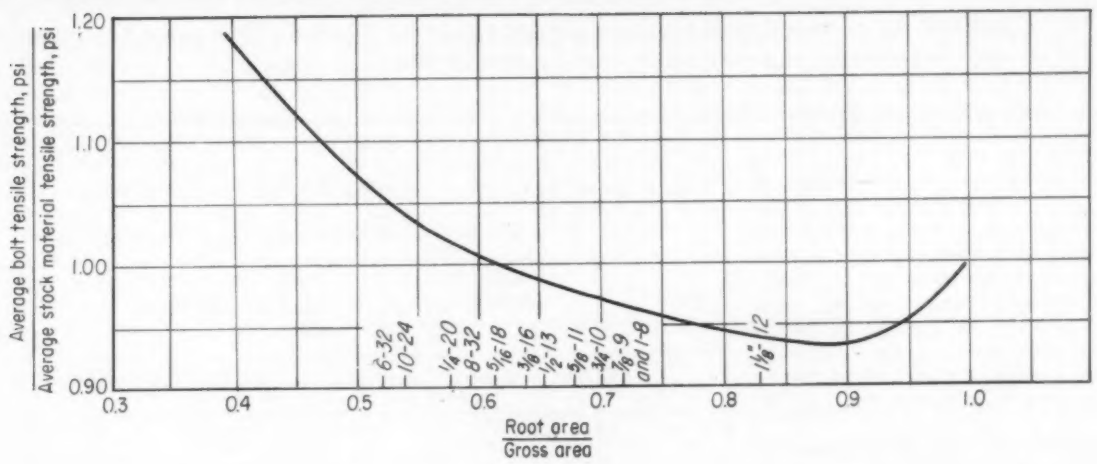
TABLE V Shear strengths of aluminum alloys

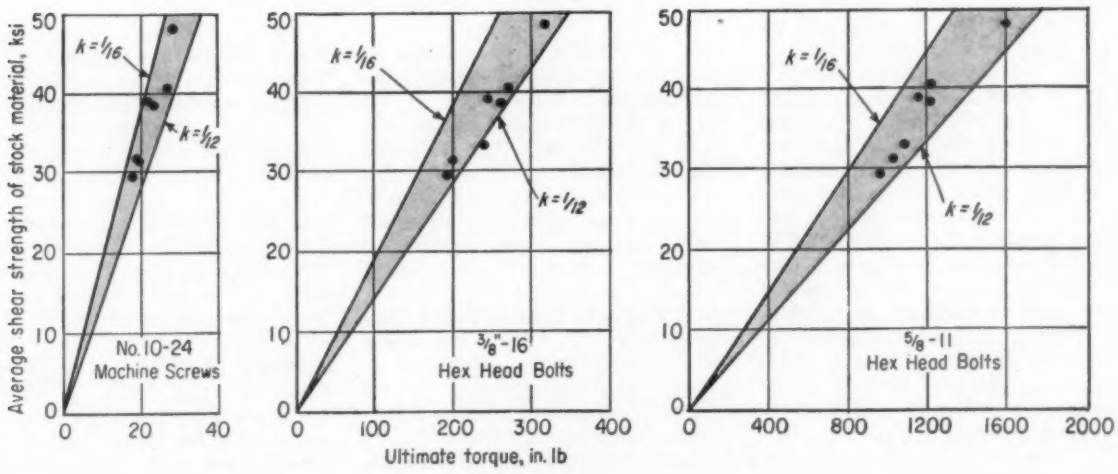
ALLOY AND TEMPER	SHEAR STRENGTH PSI	ALLOY AND TEMPER	SHEAR STRENGTH PSI
6061-T6	29,500	2014-T4	38,600
6061-T81	31,500	2024-T4	39,000
6061-T911	31,800	2014-T6	40,500
2011-T3	33,200	7075-T6	48,100

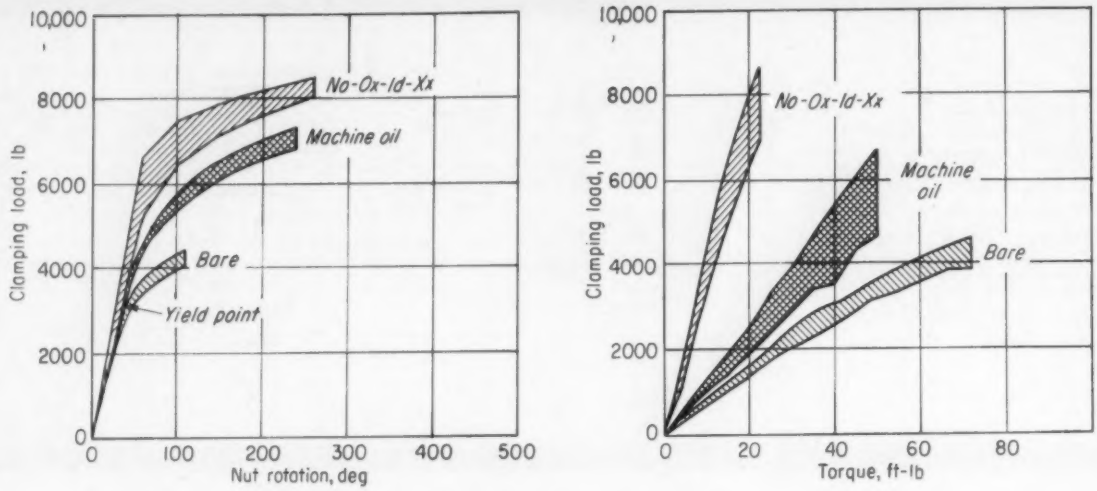

Steel tension testing fixtures


Hardened steel wedge
Steel tension testing fixtures


Bolt
A calibrated torque wrench is used to apply torque through the nut
Vise
Plate material
Washers
Calibrated load cylinder equipped with electrical strain cages
Bolt head (bolt head is restrained with socket wrench)


Average bolt tensile strength, psi / Average stock material tensile strength, psi
1.20
1.10
1.00
0.90
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
6-32
10-24
1/4-20
8-32
5/16-18
3/8-16
1/2-13
5/8-11
3/4-10
7/8-9
and 1-8
1-1/8"-12
Root area / Gross area


Average shear strength of stock material, ksi
k = 1/16
k = 1/12
No. 10-24 Machine Screws
3/8"-16 Hex Head Bolts
5/8-11 Hex Head Bolts
Ultimate torque, in. lb



4 EFFECT OF LUBRICATION is highly significant beyond the yield point when torque is measured by either calibrated torque wrench (right), or by nut rotation (left).

f, is the ultimate shear strength of the material psi; d is the root diameter of the bolt, in.; and k is between ☆ and ☆. Theoretically the constant ☆ would apply for an elastic distribution of stress over the cross sections; and the constant $\frac{1}{1\frac{1}{2}}$ would apply for purely plastic behavior. Shear strengths for the different materials in Fig 3 are given in the Table V.

Lubrication of threads is important in obtaining clamping loads. Torque-tension tests on ⅜-16, 2024-T4 bolts gave ultimate torque values ranging from 145 to 410 in.-lb. The low figure occurred when No-Ox-Id-XX (Dearborn Chemical Co, Chicago) lubricant was applied to the threads, and the high figure on specimens without lubricant. Test results, Fig. 4, show that bolts lubricated with No-Ox-Id-XX produced higher clamping loads than either machine oiled or bare bolts. For example, in Fig 4, average clamping load with No-Ox-Id-XX was about five times the value of the bare bolt at the same torque. So, if your design calls for maximum clamping, it can be obtained more readily with proper lubrication. Additional data (Table VI) shows that bolts lubricated with No-Ox-Id-XX gave clamping loads that ranged from 94 to 96% of the average tensile breaking loads at the maximum torque.

For **reprint** of above article, just check 638 on one of the Reader Service cards found in this issue.

TABLE VI Comparison of tension vs torque-clamping load capacities

BOLT SIZE	TENSION TESTS—FIG 1 AVE BREAKING LOAD LB	TORQUE-CLAMPING TESTS—FIG 1 AVE MAX CLAMPING LOAD LB	RATIO
⅜-16	5,000	4,770	0.95
½-13	8,990	8,440	0.94
⅝-11	13,900	13,400	0.96
¾-10	20,600	19,400	0.94

EDITOR'S NOTE: For additional information on threaded fasteners see the following:

How to Select Threaded Inserts, May 22 '61, p 46—Why use an insert? What types are available What factors govern their selection? How do you determine whether a particular insert meets the given strength requirements, and which is most economical?

What Torque to Tension Plated Bolts, Dec 5 '60, p 73—Shows how, for a given torque, tension will vary inversely with the coefficient of friction —which is affected by whether plating goes on bolt, nut, or washer.

Vibration Resistance of Thread-Locking Devices, Oct 10 '60, p 58—Gives new test method for rating locknuts and compares results with plain nuts.

When Expandable Bushings are the Answer, Sep 5 '60, p 41—Shows two types of expandable bushings that provide locking for many bolt and gear arrangements. They provide zero clearance of a press fit along with easy assembly.

Test Results Guide High-temperature Design of Bolted Assemblies, Sep 30 '57, p 79—Recommends materials for bolts and structures up to 1350 F; gives test results for computing effects of heat expansion.

Assembly Methods—An Engineering Roundup, June 8 '59, p 91—Diagrams for sheet metal fastening, die-cast parts, glass, plastics, spring joints, brazed joints, and detailed checklist of additional information on assembly methods and materials.

—Frederick Marich

Capacitors handle load current:

Torque-motor drive

A dc shunt motor run with capacitor and rectifier in series has high stall torque and stays cool.

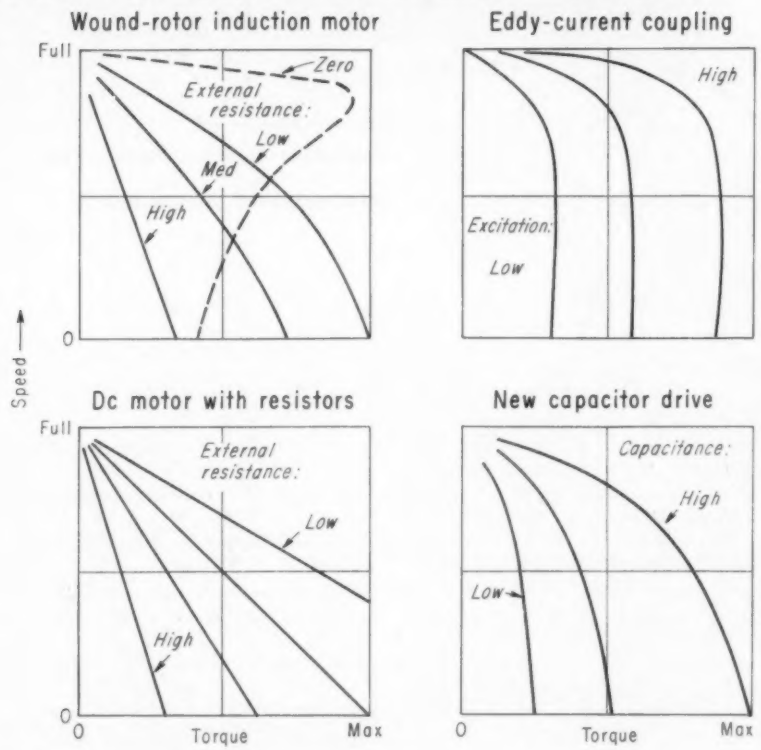
ARAM KALENIAN, president and chief engineer, Vee-Arc Corp, Westboro, Mass

WHEN you want motor torque to increase directly with decrease in speed right down to stall—and to do this without burning up the motor—a special controller is needed.

Several types of stallable torque-motor drives are already well known: ac servomotors; ac wound-rotor motors; eddy-current couplings; ordinary dc shunt motors with high resistance in the armature circuit; and ac squirrelcage motors with special high-resistance armatures. All these, however, have one common fault—considerable heat is generated which must be dissipated to preclude motor failure.

Now there is a new design that has inherently low losses: a capacitor-controlled torque-motor drive (performance is compared with several typical torque motors below). The motor is an ordinary dc shunt-type motor with an independently excited field. The armature is energized with dc from a rectifier whose ac input is in series with continuous-duty capacitors; the voltage automatically adjusts itself to the load and controls are therefore simple (schematic, next page). Sizes

RELATIVE PERFORMANCE OF TYPICAL TORQUE DRIVES



SERENDIPITY RIDES AGAIN

Aram Kalenian discovered this new capacitor torque-motor drive by coincidence. In his own words it's a case of "serendipity rides again" (*PE—Aug* 14 '61, *p* 29) because he wasn't trying to invent anything specific. He was just testing the failsafe features of a previous invention, the Reactron (*PE—Mar* 28 '60), by short-circuiting the inductive reactor, leaving only the capacitance in series with the motor armature. He discovered that no damage was done, but that the speed dropped excessively with increased load—safe but undesirable characteristics for a machine-tool drive. By coincidence, designers of wire- and yarn-winding machines recently came to Vee-Arc searching for a spool drive with just such characteristics. So Aram put two and two together and made patent applications for his new drive—named the Capacitron.

from 1-watt servomotors to integral-hp motors can be made, but curves on this page are for a 1-hp version.

How new capacitor drive works

The armature with its rectifier is equivalent to a highly variable resistor —call it R_A—and this resistance is proportional to the speed of the armature as long as the field is held constant. The voltage across R_A is in phase with the current (torque is approximately proportional to current) and the voltage across the capacitor lags current by 90 electrical degrees. The vector sum of the two voltages will lag the current by an amount depending on how much of the total drop is across the capacitor.

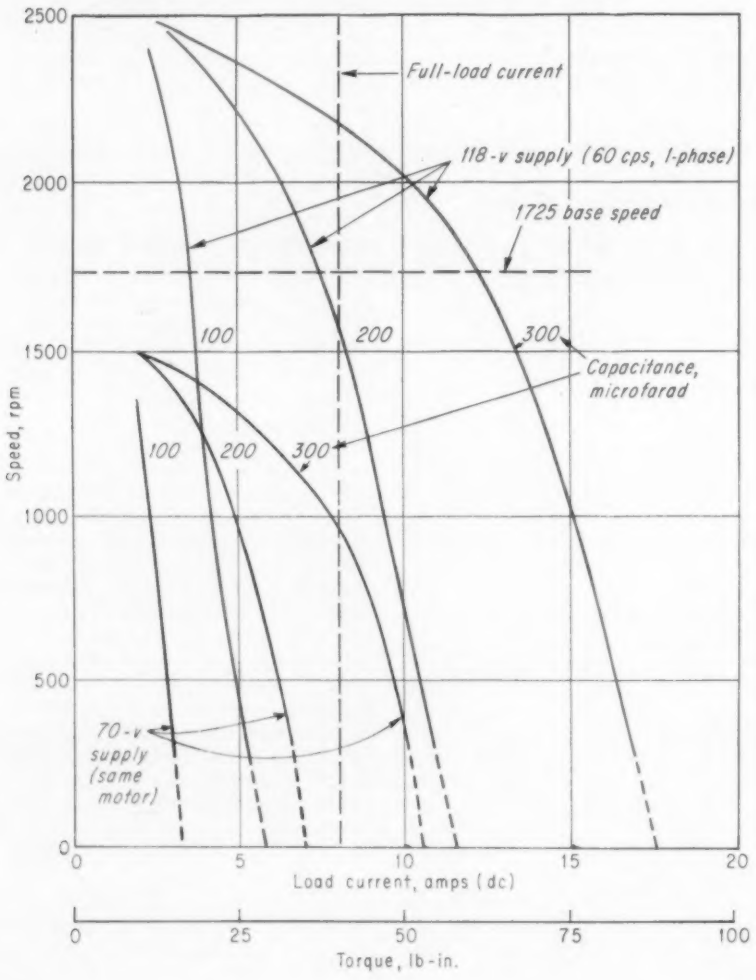
For example, suppose the motor is operating at top speed and at no load. The motor back-emf is nearly equal to the line voltage and the capacitor voltage drop is relatively small.

If external load is added to the motor, the motor speed and back-emf will drop, and a greater portion of the line voltage will appear across the capacitors. The higher motor current —in view of lower effective armature resistance caused by loss of speed— increases motor torque proportionally. The resulting higher capacitor current is "wattless" and therefore heatless because it is out of phase with the voltage by 90°. It is actually beneficial because it tends to improve the overall power factor of the system by a proportionate amount.

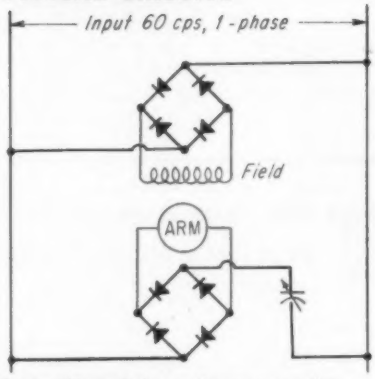
If the external load is increased to the point of stalling the motor, this automatic phase-shifting continues to a point wherein practically all of the line voltage appears across the capacitors and only a very small amount appears across the motor. Form factor of the voltage and current is practically unity over the entire speed and load range, and good-quality motors can be held in this stalled condition indefinitely at torques up to twice full-load torque without the danger of overheating the motor or controller.

The maximum no-load speed of this new capacitor-controlled motor is proportional to the ac volts impressed on the rectifiers and does not depend on the amount of capacitance in series with it—beyond a minimum. The minimum value of capacitance is that which allows sufficient current to compensate for no-load losses of a given motor. Supply voltage can be any value within the rating of the motor selected: up to 440 or more. Curves (below) show effect of chang-

PERFORMANCE OF 1-HP CAPACITOR DRIVES

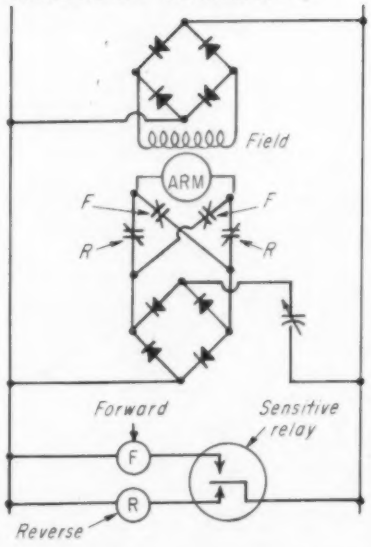


TYPICAL CIRCUITS



Capacitor-driven torque motor

Bidirectional servomotor †



ing supply voltage from 118 to 70 v on a 1-hp motor.

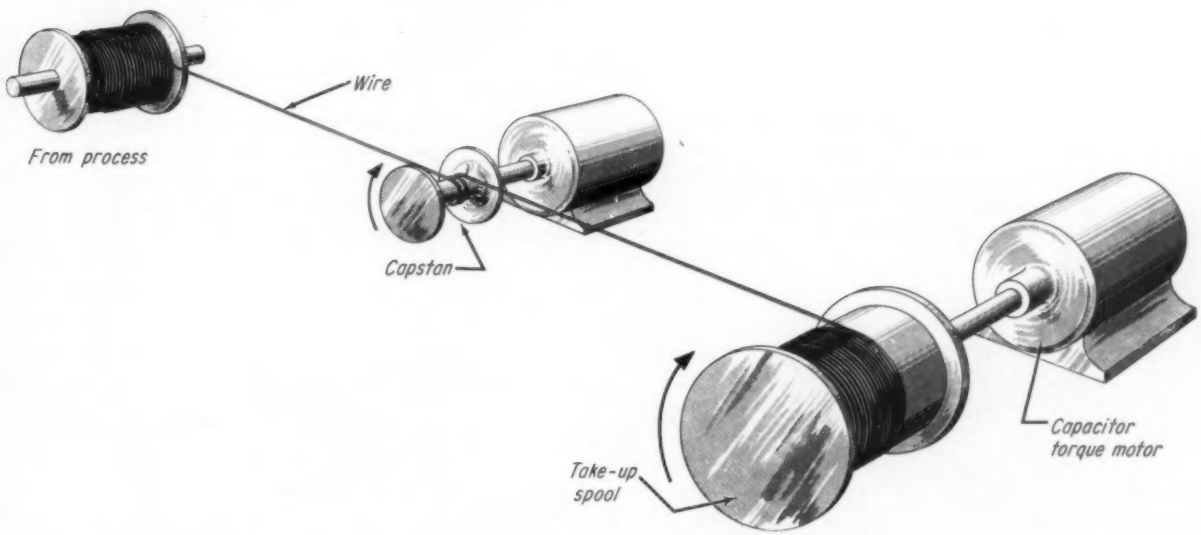
This new drive has certain advantages over conventional torque drives. There are no electron tubes, rheostats or external resistance banks to create unwanted heat—the capacitor inherently and immediately adjusts motor armature voltage in response to load simply by changing the phase relationship between current and voltage. Phase shifting is so quick and complete that the rectifiers can be shorted without harm. Excessive current is not possible under any circumstance, even at full stall, because a capacitor of proper size to match motor characteristics has a maximum limit which cannot be exceeded even if full ac line voltage is impressed across its terminals. Excessive speed is not possible, even with complete loss of load; the curves on the previous page show how speed tapers off at maximum.

One unique application is for a closed-loop bidirectional dc servomotor controller (schematic on previous page). It can hold the motor in stalled condition indefinitely with negligible power loss across the armature. An error signal of less than one microwatt across a supersensitive polarized 3-position null-seeking amplifier relay will immediately start and run the motor in the proper direction with accelerating torques in excess of five times full-load torque and stop it almost instantly when the error signal reaches null.

Another application for this stallable torque motor is to drive the take-up spool on wire-, tape, or yarn-winding machines. The wire or other similar material from the process (shown as a large roll in the sketch below) is pulled off at constant speed by a power-driven capstan or equivalent, and is wound onto the take-up spool at proper speeds and tensions.

The take-up drive must be readily adjustable to match winding-machine requirements and characteristics so that tension and linear speed will remain constant to avoid slack or breakage as the wire leaves the capstan. The take-up spool must decrease in rpm directly with increase in spool diameter to maintain constant linear speed. The torque of the take-up motor must increase with spool diameter to maintain reasonably constant tension. A capacitor drive inherently has the necessary torque-speed characteristics and no feedback control is ordinarily necessary.

CAPACITOR TORQUE MOTOR ON WIRE WINDER



EDITOR'S NOTE: Many new concepts in speed controls for motors have appeared previously in our pages. Here a few:

Variable-speed Motor Drive, Mar 28 '60, p 80—Author Aram Kalenian describes his reactor-capacitor drive (the Reactron). It holds constant speed at any load because of inherent phase-shifting between the capacitance and the inductive reactor.

Speed Control for Dc Motors, Aug 15 '60, p 41—Introduces a variable-speed motor drive that has silicon controlled rectifiers with magnetic-amplifier triggers. There are no electron tubes and the control is very compact.

Putting Eddy Currents to Work, Oct 16 '61 p 93—The eddy-current effect is useful in clutching and in speed control. This article reviews theory and applications.

Spherical-type Variable-speed Motor, July 7 '58, p 68—Analyzes British-made skewable-stator induction motor that varies in speed when stator angle is changed.

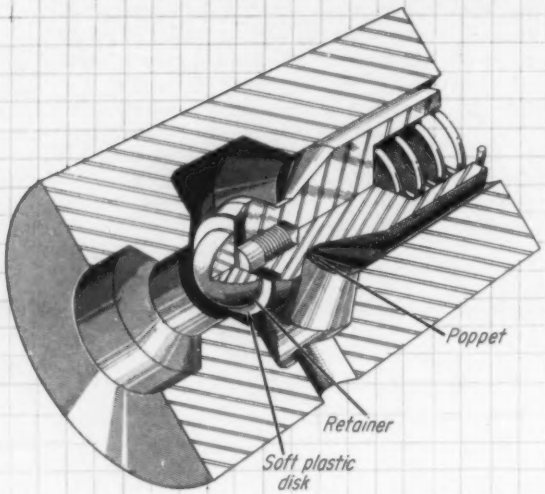
Torque Motors and Brakes, Apr '57, p 146—Gives theory and performance of polyphase induction motors designed for extremely high slip.

A complete bibliography of all our articles on motors, including torque motors and motors for high-inertia loads, is found in: **Here's Help in Selecting the Right Motor,** Oct 13 '58, p. 86. *—F D Yeaple*

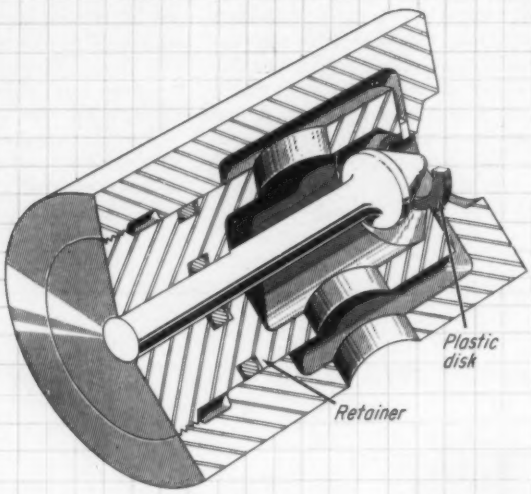
8 Ways to make a

Low seat forces can keep a tight seal—even for metal-to-metal seatings.

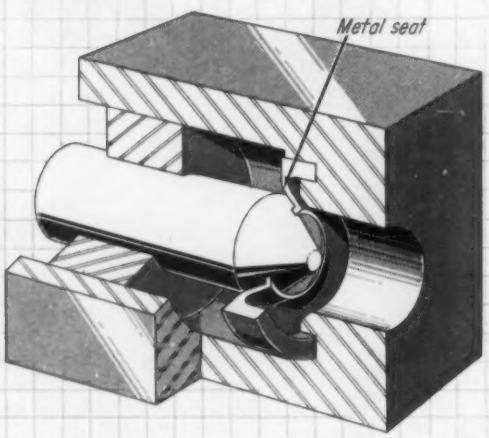
DOMINIC J LAPERA, design engineer, Marotta Valve Corp, Boonton, NJ



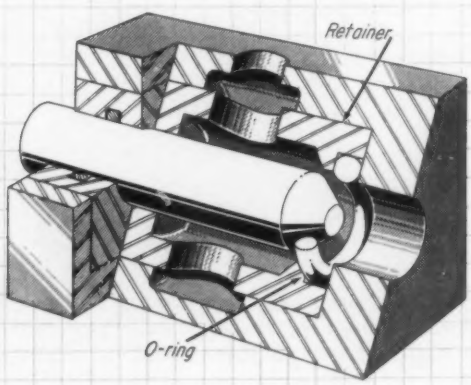
1 **CAPTIVE DISK** keeps bubble-tight seal when spring pushes it against conical seat in valve body. This, the most common design, is often found in checkvalves. It gives reliable service.



2 **CONICAL STEM** bears against sharp corner of soft plastic disk. Concentric retainer, which screws into the valve body, holds disk in place which is located by recess in body.



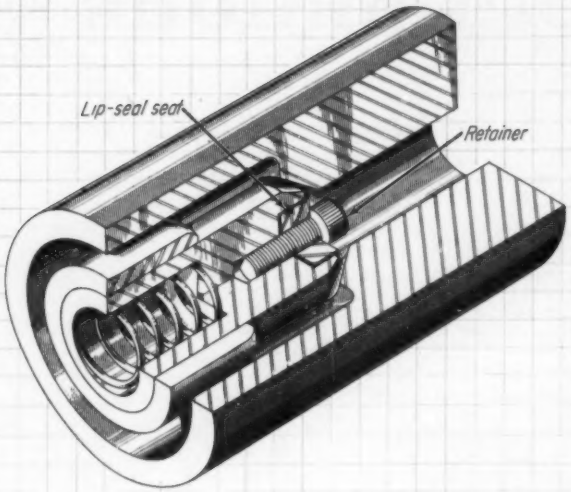
5 **FLEXIBLE METAL SEAT** can stand higher temperatures than plastic, but because flexing takes up some irregularities, it doesn't require the high seat loads normal with metal-to-metal valves.

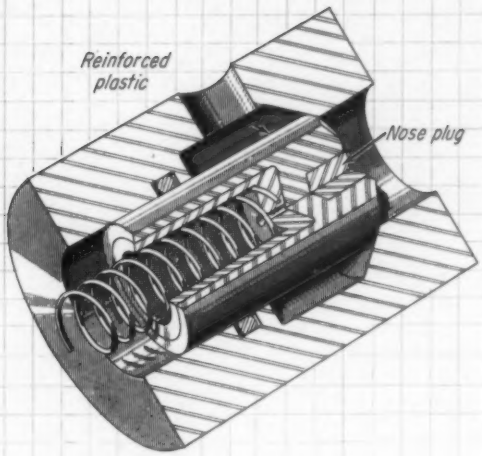


6 **O-RING SEAT** will open at same pressure as consistently as much more expensive valves. However, cracking pressure must be quite high when compared to pressure at the normally rated flow.

PRODUCT ENGINEERING
NOVEMBER 13, 1961

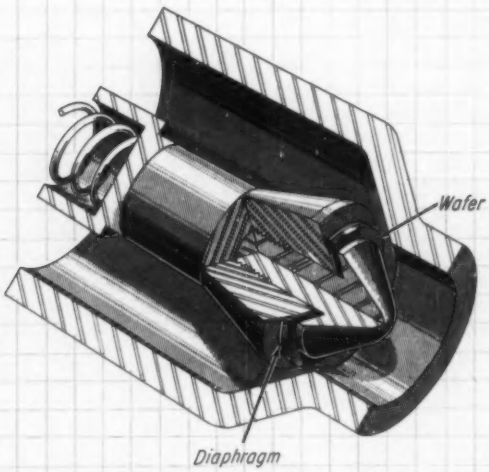
poppet valve

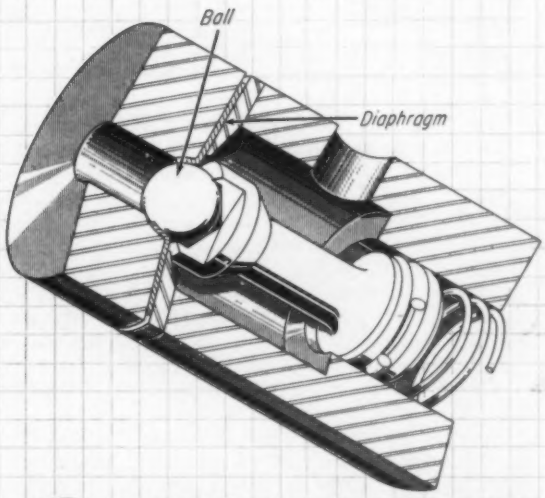




3 **LIP-SEAL SEAT** requires smallest force to be bubble-tight. Large forces flatten lip, so design works best when differential across seat is low. Example is a relief valve where fluid pressure opposes spring force.

4 **PLASTIC POPPET** cannot stand shock loading. Accurate machining for a good seal is easy because poppet guide and seat are in the same piece. Best angle between cone and seat is 20 to 30°.





7 **METAL DIAPHRAGM** backs up seat wafer and presses it to contour of the cone. This compensates for irregularities common on large valves. Wafer must be thin enough not to wrinkle when deformed.

8 **BALL** forces plastic diaphragm against spherical seat. Vent will keep pressure from building up behind the ball which is not a force-fit in socket. Spring strength determines cracking pressure.

For miniaturized gear systems

Enlarged-tooth pinions

Here's how to increase the number of teeth in contact and thereby avoid undercut when you want fewer—but larger—pinion teeth.

RICHARD L THOEN, staff engineer, General Mills Inc, Minneapolis

MANY of the gearing problems associated with miniaturization can be avoided by resorting to pinions with small number of teeth. But the trend today is in the other direction—toward specifying ever finer pitches. It may surprise most gear designers to know that we have generated—with conventional hobs—pinions having as few as four teeth; and, with special form cutters, pinions having as few as three teeth (Fig 1 and 2). These fewer teeth result in larger, stronger tooth forms, higher contact ratios (number of teeth in mesh), and fewer of the manufacturing and inspection problems inherent to the ultra-fine pitches.

At present, if you follow the standard procedure for modifying pinions you will not be able to come up with optimum results. By "optimum" we mean pinions that yield the maximum contact ratio. In fact, before the contact ratio can be determined, it is necessary to compute the amount of undercut—a rather laborious computation.

The graphs presented here give a clear picture of the variables that influence the optimum tooth proportions of modified pinions. It will be shown, for example, that decreasing the pressure angle actually increases the contact ratio of enlarged pinions—a favorable result, and contrary to popular opinion. Included in this analysis are proposed tooth proportions of a generating rack (or hob) which, it is hoped, will be standardized by the industry for the production of pinions of all pitches in the fine-pitch category — 20 diametral pitch (DP) and finer. This hob is one of the many standard hobs now employed in the industry—hence, in many cases, special tooling costs will be unnecessary.

Ease of fabrication

The pinions and gears in Fig 1 were generated with the same hob. The hob also generates the pinion outside radii. This offers all the manufacturing and inspection advantage of top hobbing; but, unlike topped gears, the outside radii are not dependent upon the dimensions and tolerances of a topping hob. Also, because of their relatively exposed tooth surfaces, the pinions can be checked for tooth-thickness by span-gaging with a conventional micrometer, and measured for lead error with a simple setup consisting of a surface plate, shop centers and a comparator.

Maximum contact ratio

Key advantage of this modification system is that the pinions yield the maximum contact ratio consistent with the pinion tooth-thickness tolerance and hob-addendum dimensions. Although the system is applicable to pinions with 21 teeth and fewer, it is best for pinions in the range of 4 to 12 teeth.

The gear addendums are enlarged—they will vary from 1.0 (standard) to 1.5. This dimension, which is the addendum of a 1 DP tooth, will increase as the number of pinion teeth decrease. The gear-tooth thickness is standard ($\pi/2$), with bilateral tolerances, which minimizes inventories of stock gears, master gears, measuring pins and cutting tools.

Because of the enlarged pinion, the center distance should be increased to avoid reducing the thickness of the mating gear, Fig 3. This illustration shows an 8-tooth pinion meshing with two gears, one of standard tooth thickness at enlarged center-distance, and another of reduced tooth thickness at standard center-distance. In general, the standard tooth-thickness system is more desirable than the standard center-distance system. The hob proportions will be described later.

The manner in which contact ratio varies with enlargement is shown in Fig 4. The tooth forms are for 9-, 18- and 36-tooth gears, all drawn to the same diametral pitch (1 DP, for example). The generating rack has a 1.0 dedendum, a 1.6 addendum and a 20° pressure angle. The gear enlargements correspond to rack offsets of zero (standard center-distance), 1.0 and 2.0. At zero offset all three gears are topped, the 9- and 18-tooth gears are undercut, and the 36-tooth gear is not undercut. At an offset of 1.0 the conditions are the same except that the 9-tooth gear is pointed and the 18-tooth gear is not undercut. At an offset of 2.0 all three gears are pointed and are not undercut.

Referring to the 9-tooth gears, the contact ratio (with a rack) is less for the condition of zero offset than for 1.0 offset. The detailed manner in which this contact ratio varies, plus that for the 18 and 36-tooth gears, is shown in Fig 5. The maximum contact ratio occurs at the transition point between undercut and no undercut. (The 36-tooth curve peaks at a negative offset.) Mathematically, this point occurs at an offset equal to

$$\Delta C = a_R - \frac{N}{2}\sin^2\phi_n$$

where ΔC = rack offset, a_R = generating rack addendum, N = number

of teeth and ϕ_n = standard pressure angle.

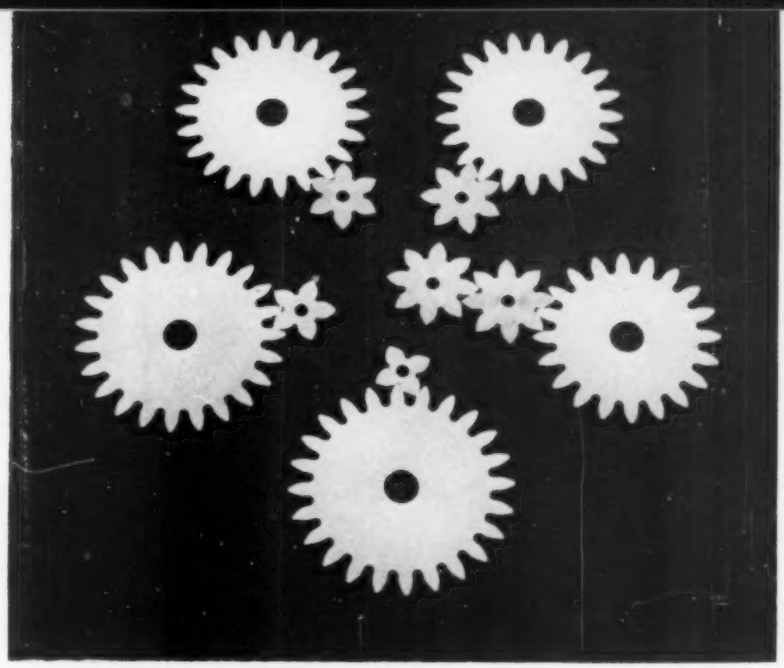
The maximum contact ratio increases with rack addendum (a_R) and number of teeth, Fig 6. Only the peaks of curves, such as in Fig 5 for a 1.6 addendum, are plotted in Fig 6. Compare, for example, the peak of the 9-tooth curve in Fig 5 with the value for the 9-tooth curve at 1.6 addendum in Fig 6. With standard pinions, the contact ratio decreases as the rack addendum increases (a semifinishing hob produces more undercut than a finishing hob). Thus, you can enlarge pinions (to avoid undercut) and obtain higher contact ratios by employing a long-addendum cutting tool. In fact, the 3-tooth pinion (Fig 2) requires a cutting tool that is almost pointed.

Because the maximum contact ratio increases as the tip width of the cutting tool decreases, Fig 6 is replotted in terms of rack tip width, Fig 7. To show also how the maximum contact ratio varies with pressure angle, only the 4-tooth curve of Fig 6 has been plotted in Fig 7. Compare, for example, the 4-tooth curve at zero tip width (2.16 rack addendum) in Fig 6 with the 20° curve at zero tip width in Fig 7.

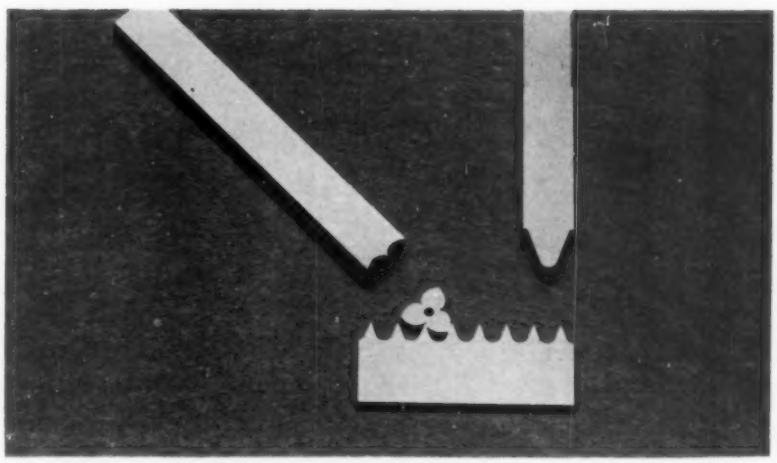
Importance of tip width

Contrary to common opinion, Fig 7 shows that the maximum contact ratio of enlarged pinions varies inversely with pressure angle. As an illustration, a tooth modification system based on 14½°, 0.4 tip width offers slightly greater possibilities than one based on 25°, 0.4 tip width. In short, from the standpoint of maximum contact ratio, a cutting tool should have a long addendum and low pressure angle.

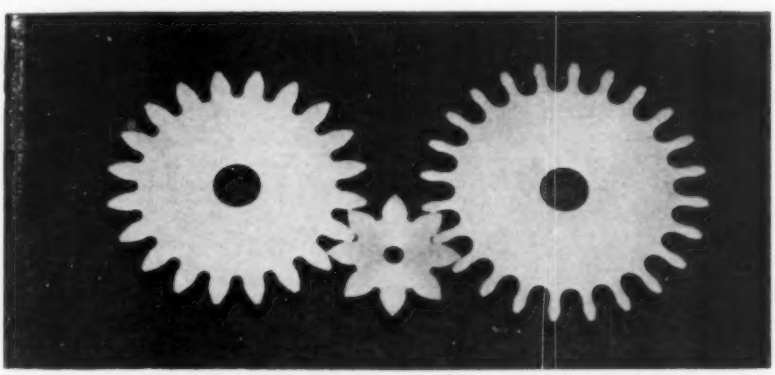
Thus, the system for modifying pinions should be based on tip width, (which is inversely proportional to the rack addendum). However, the tip widths of present-day cutting tools are not constant—they vary with the diametral pitch. For instance, Fig 8 shows how the active addendums of 20°, non-topping, Class A hobs vary over the range of 20 to 120 DP. The upper curve represents a sharp-cornered semi-finishing hob and is dependent upon the 0.002-in. clearance constant, tooth-thickness tolerance, and tooth-thinning allowance. The effect of tooth thinning has been included because many semifinishing hobs are used as finishing hobs. The lower curve represents a round-cornered finishing hob, and is dependent upon the 0.002 constant, tooth-thickness tolerance, tip-radius allowance,



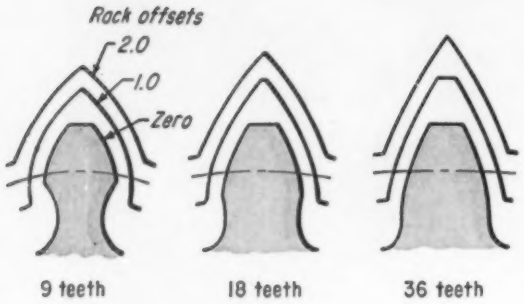
1 ENLARGED-TOOTH PINIONS — one with only 4 teeth — and gears generated with the same hob.



2 A 3-TOOTH PINION and rack formed with special form cutters illustrated.



3 ENLARGED-TOOTH PINION can be meshed with gear at enlarged center-distance (left), or at standard center-distance (right). Gear at left has standard tooth-thickness; tooth thickness for gear at right is greatly reduced.



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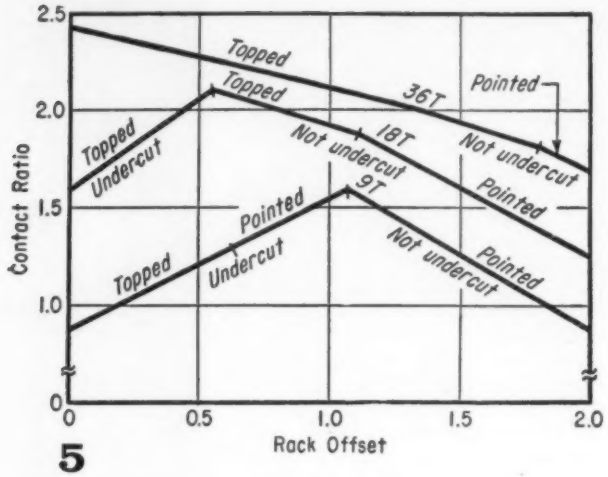

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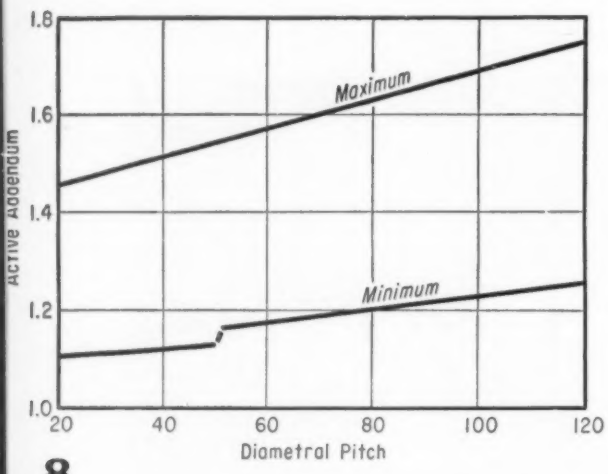

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4 **EFFECT OF ENLARGEMENT** on tooth form is seen here.

5 **CONTACT RATIO** and tooth form vary with offset of generating rack. A high contact ratio is key design goal.

6 **RACK ADDENDUM** — its influence on the maximum contact ratio.

7 **THE RATIO** of maximum contact versus rack tip width.

8 **ADDENDUM VARIATION** on fine-pitch hobs employed in gear industry. This variation can be avoided.

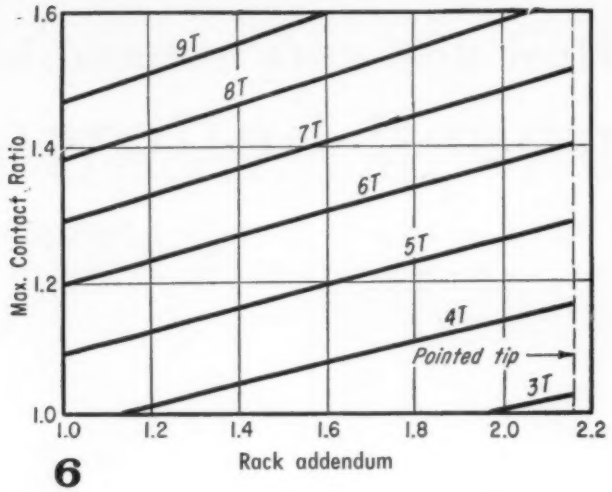
9 **UNDERCUT** on 20 and 120 DP standard 12-tooth pinions.

10 **TOOTH PROPORTIONS** of author's generating rack to produce modified pinions and standard gears.

and tip-radius tolerance. The values for tooth thinning and tip radius (which are slightly different from standard) were taken from a hob manufacturer's catalog.

In the application of pinions with small tooth numbers, the contact ratios usually are small and so it is important to know the generated radial dimensions, namely, the generated root radius, inside form radius, outside form radius and outside radius. The determination of radial dimensions is time-consuming, especially the inside form radius when the pinion is undercut. (Actually, there is relatively little need for modified pinions with 12 teeth and more. The undercut that occurs on a standard pinion is usually advantageous in that the undesirable portion of the involute near the base circle is removed, thereby permitting a more generous tolerance on the outside diameter of the mating gear, and roll testing with a standard master gear.) From a designer's standpoint, therefore, variation of hob addendum with pitch is an inconvenience in that the generated root and inside form radii cannot be determined once and for all. Instead, each pitch must be treated separately. To illustrate this, Fig 9 shows two 12-tooth standard 20° pinions generated with sharp-cornered semifinishing hobs, one with a 20 DP hob (1.46 addendum) and the other with a 120 DP hob (1.75 addendum). Allowing for the standard 0.1 outside radius tolerance, the contact ratios (with a rack) are 1.06 for 20 DP and 0.97 for 120 DP. Further, these contact ratios would be less if conventional tolerances for pinion tooth thickness and top land runout (which also vary with pitch) were applied.

It is best if the tooth proportions of the generating rack do not vary with pitch. We have been employing the generating rack (hob) shown in Fig 10 for modified pinions and standard gears. It is independent of pitch, and as desired, the tip width is narrow but not narrower than the generally regarded practical limit. In the range of 20 to 146 DP the addendum tolerance (1.6—1.5 = 0.1) is greater than the addendum tolerance for Class



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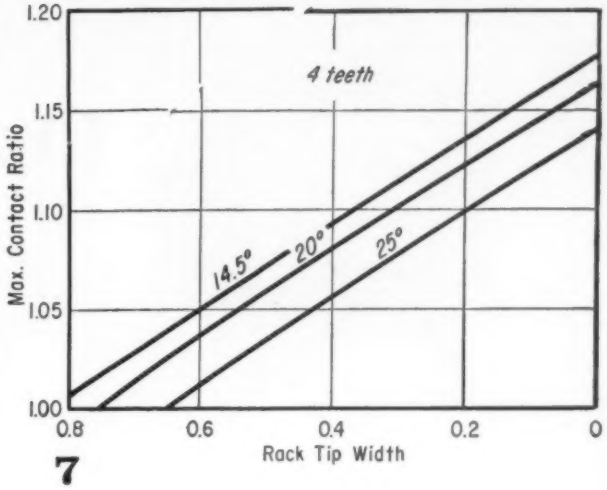

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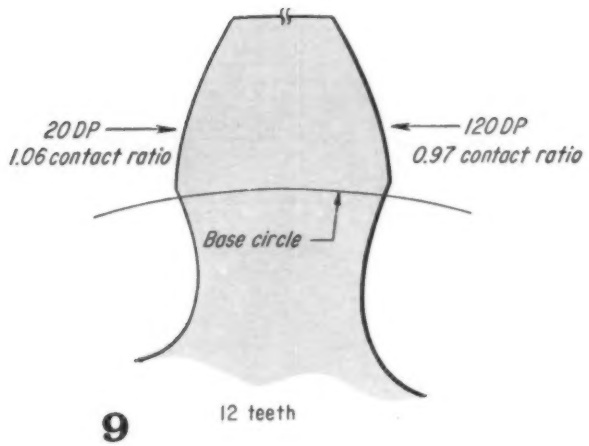

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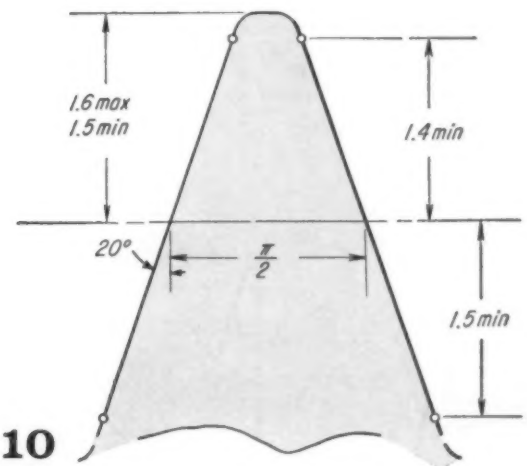

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A hobs. The tip and root forms are not specified.

Two of the hobs standardized by the gear industry have these properties—the addendum limits of 64 DP semifinishing and 150 DP finishing Class A hobs lie between 1.5 and 1.6. In adjacent pitches, it is possible to find hobs with addendums that measure from 1.5 to 1.6, namely, semifinishing hobs in the range of 24 to 96 DP and finishing hobs in the range of 120 to 200 DP.

With a generating rack that is independent of pitch, it becomes practicable to tabulate the dimensions of modified pinions and of standard pinions with undercut. We have prepared such tables with the aid of digital computers. Only a few tables need be constructed, say 3 to 5 based on tooth-thickness tolerances, not a series of tables based on combinations of pinion-tooth thickness and diametral pitch.

For all practical purposes the fillet curve generated by a hob is the same as the fillet curve generated by a rack; therefore, tables based on a generating rack are applicable to hobbed pinions. The fillet curve generated by a circular shaper cutter differs in that it depends also upon the number of cutter teeth and the amount of required sharpening. Consequently, as in any modification system, pinions that are produced with circular shaper cutters will require special treatment.

EDITOR'S NOTE: This article is based on a paper presented by the author at the semiannual meeting of the American Gear Manufacturers Association in Chicago, two weeks ago.

The AGMA has recently come out with a new gear classification system for specifying quality, materials and heat treatment. For details, see:

New AGMA Classification System for Gears . . . widens quality range—classifies materials, July 10 '61, p 68—The system covers spur, helical and herringbone gears, sets up 16 new quality classes, and assigns code numbers to gear materials. For free reprint, check 615 on one of the Reader Service Cards.

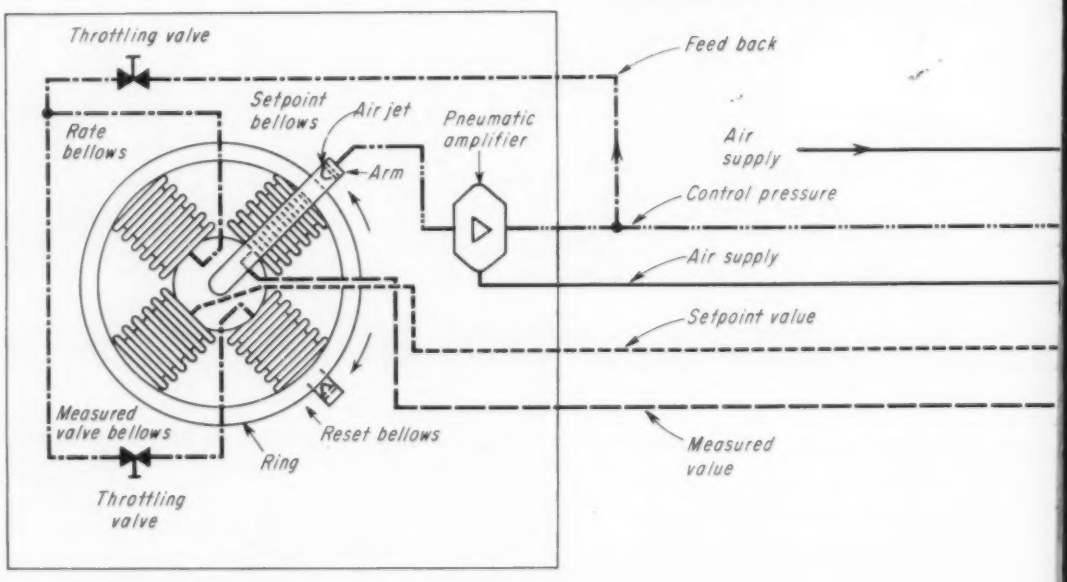
—Nicholas Chironis

Flow and rate sensed by

Opposed-bellows

Suspended ring is shifted by four air bellows which compare pressures to set flow-control valve.

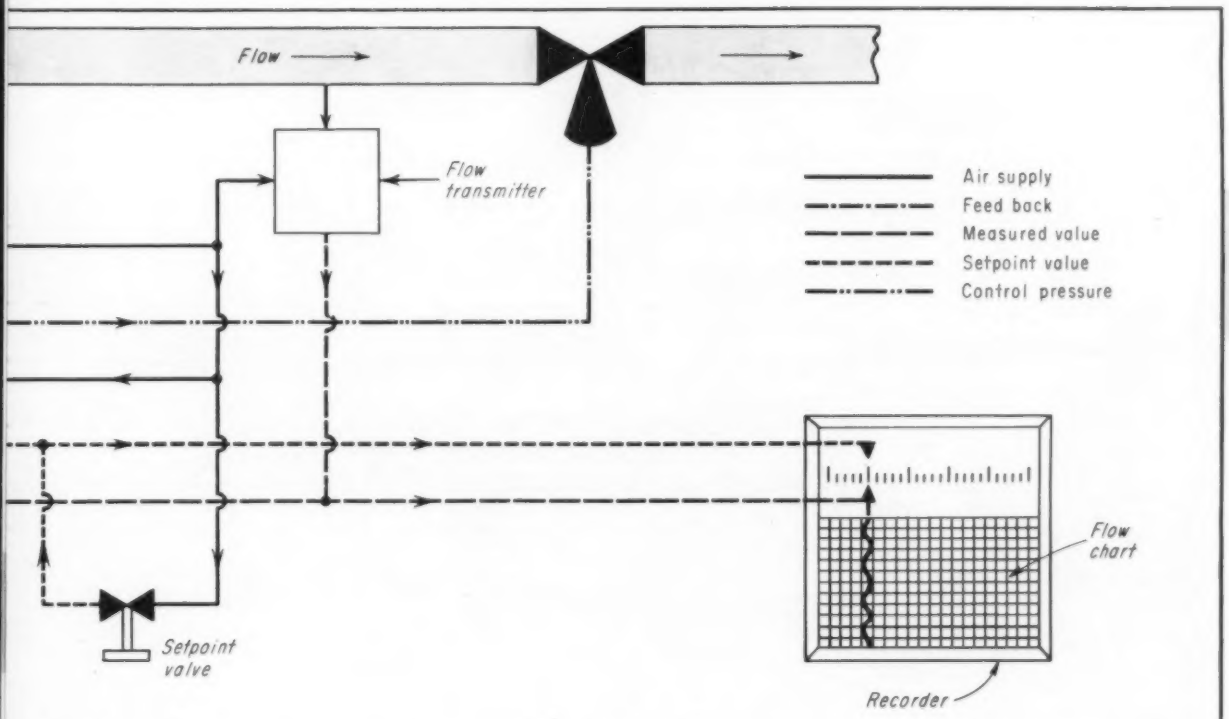
PNEUMATIC controller uses opposed bellows to compare pneumatic pressure signals produced by a flow-measuring transducer and control circuits. Pressure differences, indicating flow variations; shift the ring encircling the bellows. Ring motion is sensed by an air jet aimed at the outer surface of the ring. When the ring shifts, altering the gap between ring and jet, pressure in the air jet supply line changes. These pressure deviations are amplified to adjust a flow-control valve to the desired value. Rate of change of pressure is applied to a second set of bellows which add to the control signal to reduce control oscillations. Strip-chart recorder may be added for permanent record. Pneumatic controller is produced by J C Eckardt AG, Stuttgart, Germany.



CONTROLLER is connected to flow-control system to maintain constant flow through a pipe. Actual flow down the pipe is measured by the flow transmitter whose output is a pneumatic pressure signal proportional to liquid flow. This pressure signal is piped to the measured-value bellows, indicated on the lower pointer of the recorder, and recorded on the flow chart as actual flow. The setpoint pressure signal is produced by throttling supply air with the setpoint valve and applying the result to the setpoint bellows. This pressure is indicated as selected flow on the upper pointer of the recorder. Pneumatic pressure in the setpoint and measured-value bellows exert opposing forces which act on the ring. If the setpoint and measured pressures are equal the forces cancel each other, the ring remains stationary, and control pressure to the flow-control valve unchanged.

If a flow deviation occurs the pneumatic signal from the flow transmitter to the measured-value bellows changes,

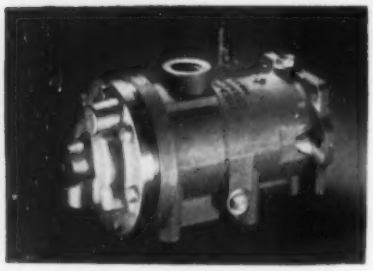
pneumatic servo control



displacing the ring. The air bleed through the nozzle is increased or decreased, changing the pressure in the air line. The changing pressure is applied to a pneumatic amplifier whose output actuates the flow-control valve to restore flow to the setpoint value.

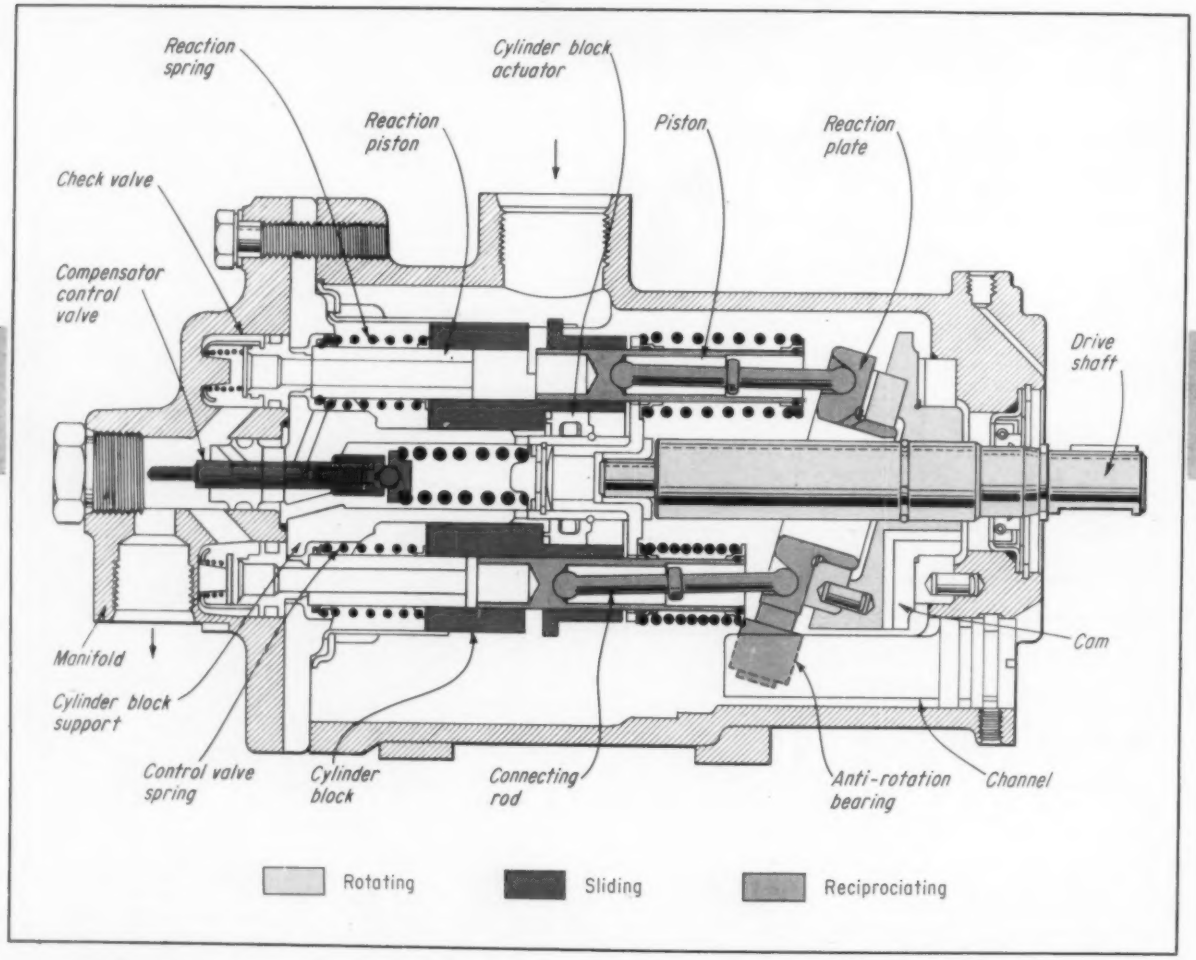
The ring shift in response to flow deviations is modified by feedback of the amplified control pressure to the opposed rate and reset bellows. A time lag is introduced by inserting a throttling valve to slow feedback flow to the rate bellows. A second throttling valve between the reset and rate bellows ultimately cancels this negative feedback. Both throttling valves are adjustable to achieve the desired feedback rate.

Amplification is controlled by altering the position of the air jet arm around the circumference of the ring. Maximum amplification is provided when the arm is in line with the setpoint bellows. As the arm is rotated toward the reset bellows the influence of the rate bellows on control pressure and feedback is increased.



Moving cylinders

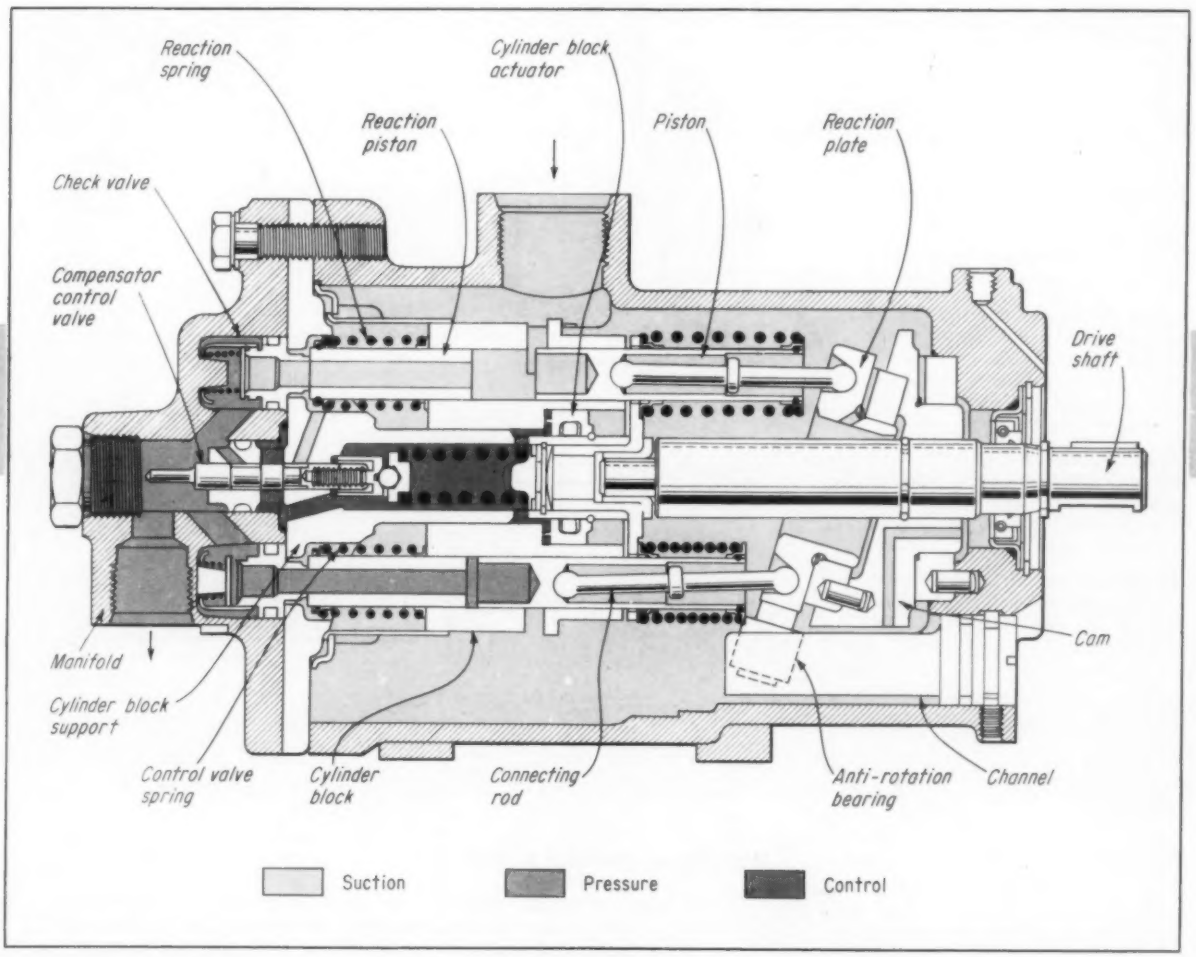
Cylinder block is axially shifted—either manually, by servo, or by discharge pressure—to control displaced volume.



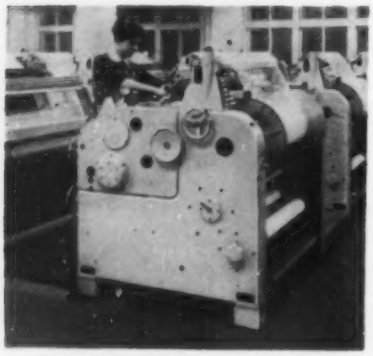
CYLINDER BLOCK has seven cylinders, each with its own piston-connecting rod and checkvalve constituting a separate pump discharging into a common manifold. On the compression stroke the piston moves to the left, closing the intake port and forcing oil through the reaction cylinder and checkvalve to the discharge manifold. Axial movement of the cylinder block on its support changes the point at which the cylinder intake ports are closed by the reciprocating pistons. By sliding the cylinder block to the right, the ports are closed sooner and an increased volume of oil pumped. Sliding the block to the left decreases the flow. The reaction plate converts the rotary motion of the cam to a linear output. The anti-rotation bearing permits the reaction plate aid pistons to oscillate as the plate cam rotates.

control pump flow

Hydrostatically-balanced cylinder block and wobble-reaction plate isolate pumping forces from the displacement-changing mechanism. Low force levels required to shift cylinder block provide fast response and stable control of pump output. Nonrotating cylinder block eliminates centrifugal forces on reciprocating parts, allowing higher operating speeds. Variable-displacement pump delivers 9 gpm at 3600 rpm at 3000 psi. The WO 7 axial-piston, variable-displacement, hydraulic pump is produced by the Weatherhead Company, Cleveland.



PRESSURE-COMPENSATED pump model is controlled by discharge pressure on the compensator control valve. When pressure in the discharge manifold drops, the control-valve spool is shifted to the left by the valve spring. This vents control pressure to the pump housing and the cylinder block is moved to the right by the reaction springs. (Shown here full right against cylinder block actuator.) This increases the volume of oil pumped by each piston stroke. When pressure in the discharge manifold rises, the control-valve spool shifts to the right, admitting output pressure to the space between the cylinder block actuator and the block. This moves the cylinder block left, reducing the volume pumped. Cylinder position and displacement can be externally adjusted by manual or servo control of the compensator valve.



Water-jet shuttle

Jet Loom uses stream of water to "throw" weft fibers, eliminating parts and reducing inertia problems.

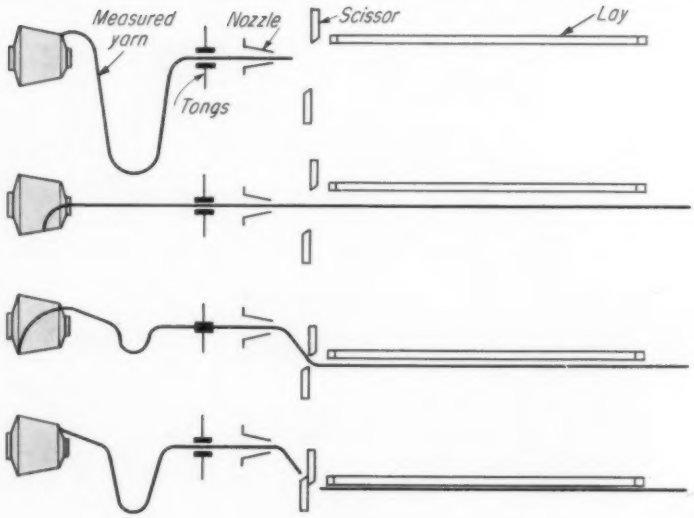
MECHANICAL loom shuttle is replaced by water jet which carries the weft thread across the shed a distance of 42 in. Monofilament fibers of 10 to 20 denier are loomed at up to 400 picks/min compared to 260 picks/min for mechanical shuttles. Improved output, reduced weight, and lower cost result from the reduction in number of moving parts achieved by use of hydraulic shuttle. Jet Loom H-105-B is sold under the Elitex trademark by Kovo, Czech Foreign Trade Corp, Prague, Czechoslovakia.

Hydraulic insertion of weft begins with the tongs opened to release a measured length of yarn. A short length of weft remaining from the last pick hangs from the nozzle.

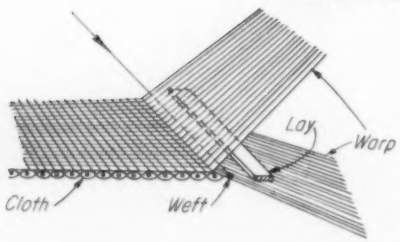
Water under pressure (85 psi) opens the nozzle and carries the measured length of yarn across the shed. When the measured length has passed through the nozzle the yarn is stopped and tensioned.

The tongs close to hold the left end of the inserted yarn firmly, and the metering drum begins to measure the required length of yarn for the next turn.

In the last step the lay travels forward to set the weft in the shed, and the left end of the yarn is cut by the scissor.

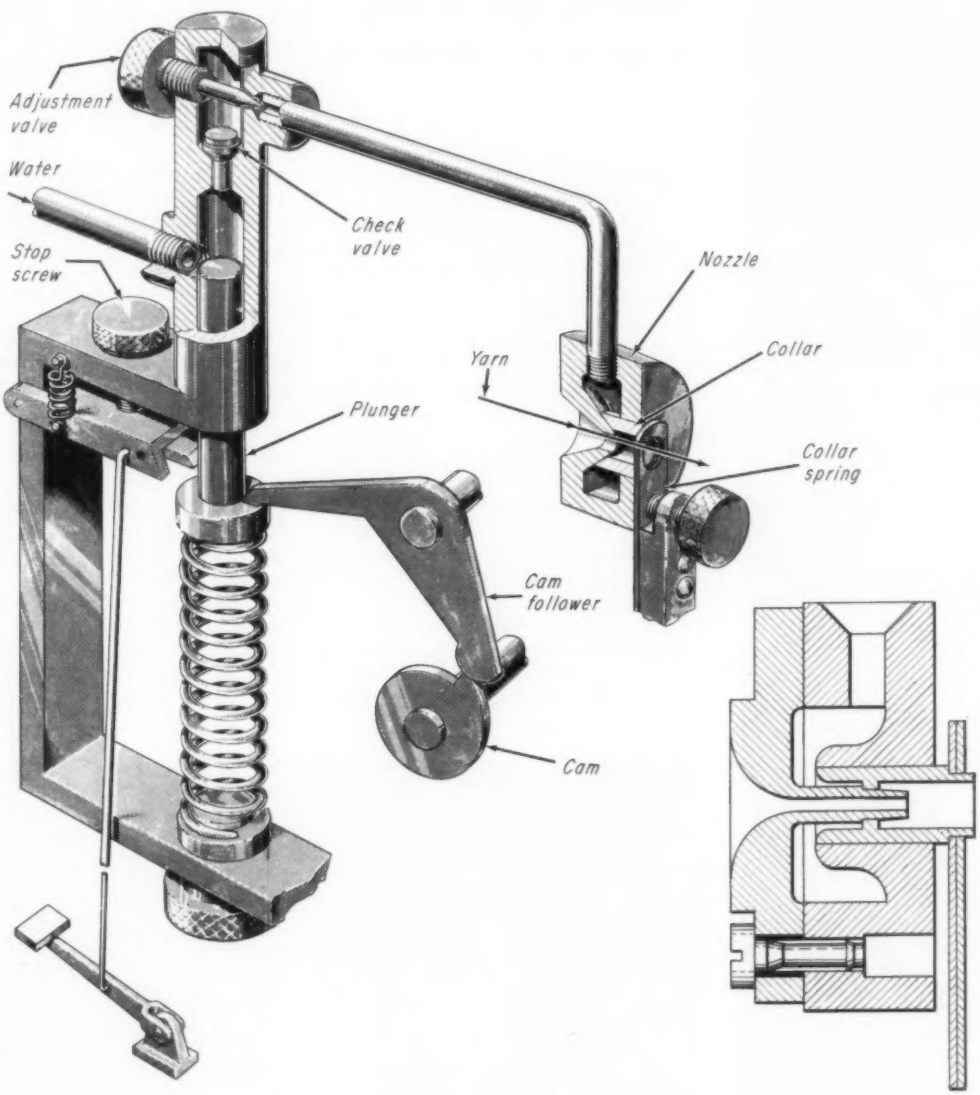


WEAVING TERMINOLOGY



In weaving, fabric is normally produced by passing a shuttle carrying the weft fiber through the "shed" formed by rows of crossed warp fibers. After the weft is inserted, the lay pushes the weft into apex of the shed. Then the lay is withdrawn, the warp fibers crossed, and the operation repeated. Each passage of the shuttle is referred to as a pick. The weft fiber is stored on a bobbin, mounted in the shuttle, which is thrown through the shed and caught at the opposite end—for return at the next pick.

speeds weaving



NOZZLE ASSEMBLY controls water jet and synchronizes weft insertion with the weaving cycle. Assembly consists of a pump, control valve, and the nozzle. Water pressure is produced by a cam-actuated, spring-loaded plunger. Foot pedal permits plunger to be actuated during set-up and adjustment of the loom by the machine operator.

As the cam rotates, plunger is pulled down by the cam follower, admitting water to the pump chamber. When cam follower passes nose of the cam, plunger is driven upward by the spring. Water passes through the checkvalve and adjustment valve to the nozzle. Pressure builds up in the nozzle until the spring-loaded collar is lifted from its seat. A column of water is ejected, picking up the yarn and inserting it in the shed. Water quantity is controlled by the stop screw and jet velocity is controlled by collar spring adjustment screw which sets min water pressure.

FLIGHT PLAN in cabin of C-131-B requires starting from kneeling position because of cabin height. Once airborne, controller is pushed forward to give rearward jet thrust. Translation is by combination of the two controllers. Landing is accomplished by a downward and rearward motion of the controller, using the legs to break floor impact Ralph Flexman, technical director of Bell's Human Factor Operation, is the pilot.

Jet belt thrusts

Called a "zero gravity belt," it can translate, position and stabilize man's nearly helpless body in the weightlessness of space.

AS RECENTLY as 1955 the thought of putting an object into space—let alone man—was still relegated to the area of science fiction. In fact, this was described as "Buck Rogerish," after the comic-strip character who for a quarter century has zipped through space, flown about planets with his own rocket belt, and repaired his war-damaged or sabotaged spaceship in the vacuum surrounding the planets.

But fiction has become reality. First, man-made objects were thrust into space, then man himself. Recently came a rocket belt that can transport man about this planet; and soon space belts will move him in the gravity-free reaches of space. For the last two items, Textron's Bell Aerosystems Co deserves the credit. The rocket belt (*PE—Sep* 18, *p* 109) is contracted to the Army Transportation Command; the space belt is a company-subsidized project that should soon be backed by hard cash from the government.

This zero-gravity belt consists of high-pressure tube bundles curved to fit snugly around the torso. The tubes are manifolded at the center of the back and terminate at the front. The thrust-controller units are attached to the tube bundle at the man's cg (center of gravity). Eight gas orifices, with integral shutoff valves for each, produce thrust through and about the cg, permitting the pilot to position himself by rotation in any of three planes and then propel himself in any desired direction.

Control actuation is simple. The operator simply pushes, pulls, lifts, depresses or rotates the hand controllers in the direction of desired motion. The system is designed for vacuum thrust

WALKING UP THE WALL of an Air Force C-131-B during weightlessness period is simple with thrust from nozzles giving directional control. To attain gravityless period aircraft describes a parabolic trajectory at a specified speed, "g" pullup, and angle of climb. Weightless period lasts approximately 15 seconds.

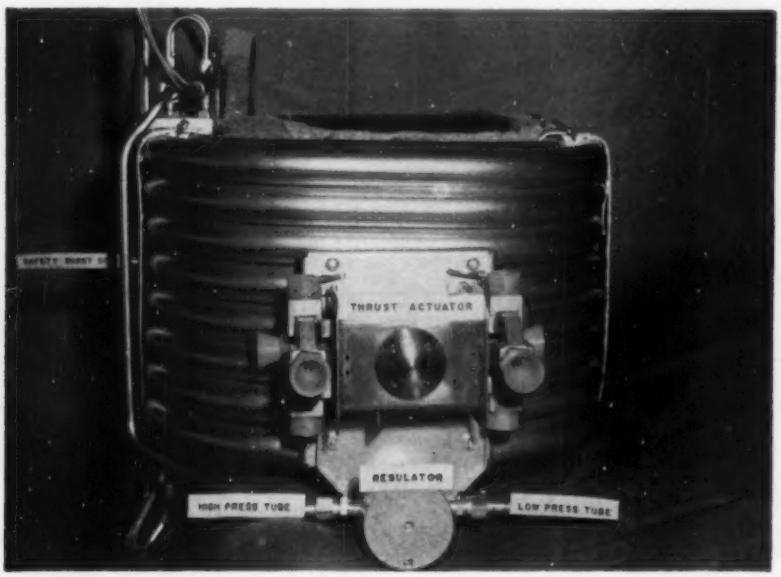
man in space

ROBERT E ABBOTT, senior associate editor

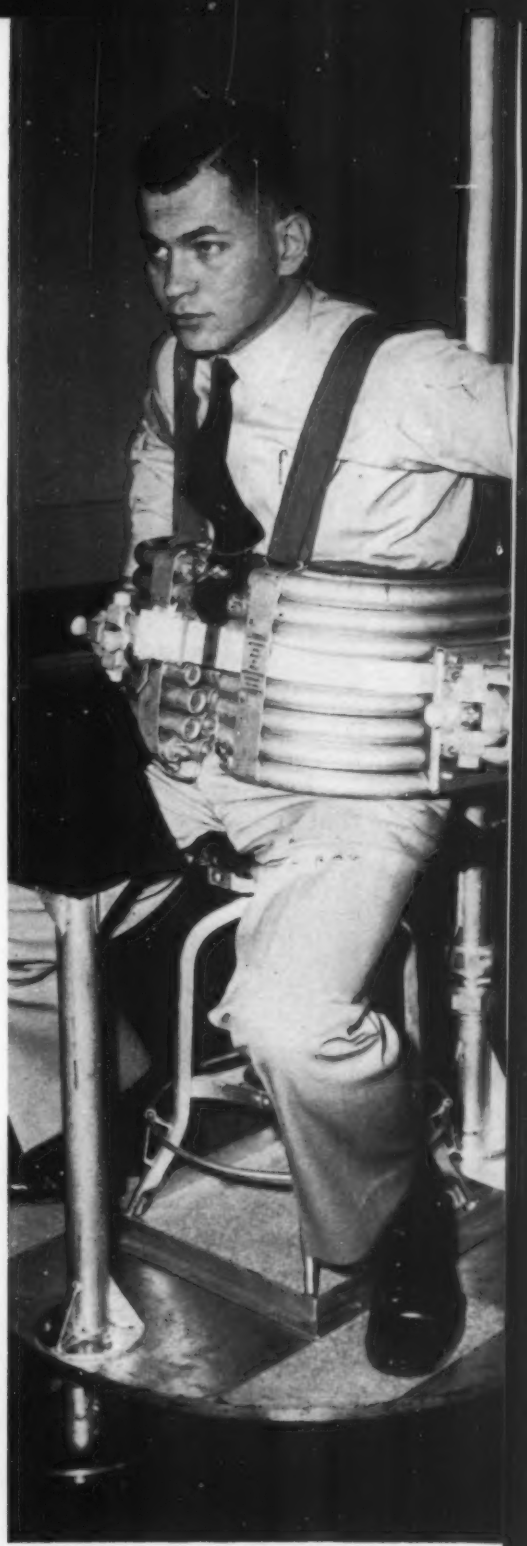
levels of either 5 or 10 lb at the orifices. Orifices used to control direction fore and aft and right and left develop 10-lb thrust, and 5-lb thrust units are used for up and down directions. Total thrust in any direction is 20 lb. Total maximum thrust duration of control valves when held full open is about 20 sec. The propellant is dry nitrogen stored at 3000 psi in the tube bundle. The high-pressure gas is reduced through a regulator to three low-pressure tubes.

Tests to date have been on Bell's air bearing platform and some 80 weightless flights aboard a C-131-B provided by the Air Force's Aero-Space Medical Laboratory. Members of the laboratory's Engineering Psychology Branch flew the belt along with Bell personnel. The parabolic flight path permits about 15 sec of zero gravity during which systematic tests are performed to prove feasibility and to demonstrate capability for stabilizing, rotating, and translating a man under conditions of weightlessness. Platform tests validated control capability and give initial training to personnel scheduled for aircraft flights. New belt and control configurations are tested on the platform.

Flight tests have pointed up three areas which require redesign. First is the need for controllable thrust. Here, thrust requirements for rotation are much less around the vertical axis than for rotation in other axes or translation. Second, the control system should be operable with either hand or be completely kinesthetic. Third, is the development of a propulsion system compatible with a true space environment and with the specific tasks to be assigned to man. Design of such a system is presently underway.



THRUST CONTROLLER combines actuator, nozzles and regulator. Six pounds of force is required to move controller up or down, fore or aft. Up and down nozzles are 5-lb units, fore and aft and lateral nozzles are 10-lb units. Total thrust in any direction is, therefore, 20 lb. New design may incorporate a center joystick control.

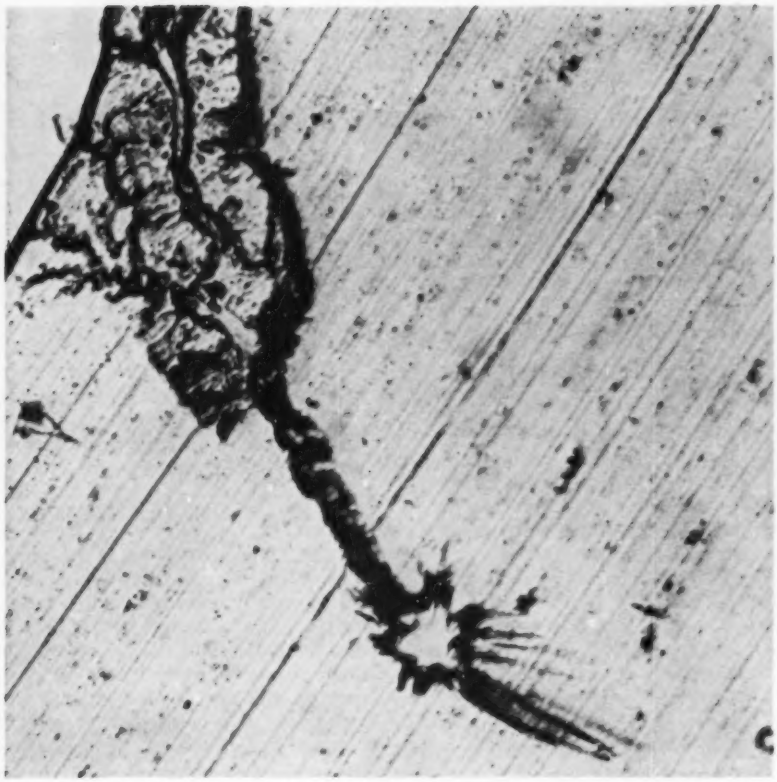


AIR BEARING PLATFORM, designed by Bell engineers, gives feeling of weightlessness for initial instruction in belt use and to check design changes. Platform is controlled by air jets on underside. Overhead piping and swivel joints deliver air from compressor to pads and control jets. Seat can be replaced with stretcher for horizontal flight instruction. Belt straps in front and is padded for comfort.

PANORAMA

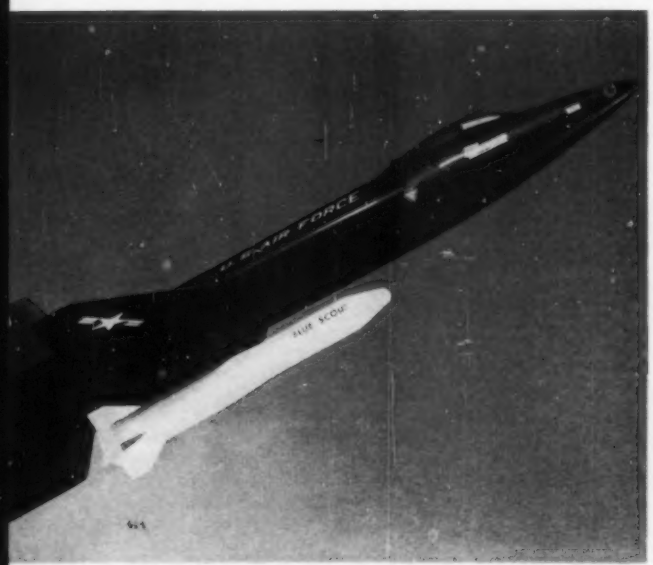
GRAPHITE CLOTH, one of the new textile forms of graphite, is here magnified 150 times. Engineers at National Carbon Co, Div of Union Carbide Corp, took a piece of cloth woven from one-ply graphite yarn and embedded it in a block of clear plastic. They sliced the specimen down the center for this picture. You see 1440 filaments per twist—which play a large role in establishing strength.

MANIPULATOR crawls through a mockup of a labyrinth in the Irradiation Processing Department Development Laboratory at GE Hanford Works. Labyrinth is part of small section put together to help demonstrate machine usefulness and to train operators in guiding it through small and narrow spaces. Manipulator is 3 ft long, 2 ft wide, and 4 ft high. An integral TV camera and light permit console operator to accurately guide the device.



PINHOLE FAILURES

In Teflon hose they frequently appear in the form of a star pattern like this one. Here, the Teflon liner of a braided stainless steel wire-reinforced jet fuel line has been split to show the inside surface. Hole can vary from 0.002 to 0.010 in. Failures occurred only in hose assemblies longer than 18 in., and never closer than 2 in. from end fittings. Aeroquip Corp, Jackson, Michigan, searched for the cause and found static electricity to be the culprit. Teflon hose of any brand, says the company, will fail if the hose can't dissipate 1 microamp at a potential of 30,000 volts. Charge is generated by selective absorption of ions at the tube wall. When the fluid is at rest the ionic charge is balanced. When flowing, a stationary charge of one sign is left on the tube wall and a charge of opposite sign is produced in the liquid. Alignment of carbon black particles embedded in the Teflon, Aeroquip reports, creates a path for the electrical charge to go to ground, permitting longer hose runs without danger of pinholing.



RECOVERABLE BOOSTER SYSTEMS are proposed by Ford Motor Co Aeronutronic Div and North American Aviation. First stage is a B-52 bomber, which carries the second stage X-15 and the Blue Scout rocket to 50,000 ft. At 156,000 ft the X-15 releases the Blue Scout for orbital or deep-probe mission. With launch start from Cape Canaveral, for example, B-52 would return to a Florida base, and X-15 would land on Grand Bahama Island.

TIRE CONSTRUCTION is easily explained with device that simulates the way tire cords change angle during molding. At right, the drum shape of a tire before molding; at left, the shape of a finished tire. Walter Lee, director of tire research and development for the Goodyear Tire and Rubber Co, Akron, Ohio, designed the device as a guide to explain technique to new engineers.

Engineers show underdeveloped areas

Designs for solar energy

These devices may not be practical for general use in industrial nations, but they may tip the scale to a better way of life for some underdeveloped peoples.

GENE DI RAIMONDO, regional editor, Milan, Italy

AT present the underdeveloped nations are energy poor—Africa, Asia, and Latin America consume less than 1/10 of the world's annual supply of conventional fuels (hydropower, crude oil, coal and natural gas). As funds and technical talent become available, these countries are developing their hydroelectric and other sources of conventional energy.

But many of their leaders do not believe large generating plants are the answer. It may be years before many communities get electricity. Meanwhile, their inhabitants need some sort of small power package to ease the burden of their work and push production beyond subsistence levels.

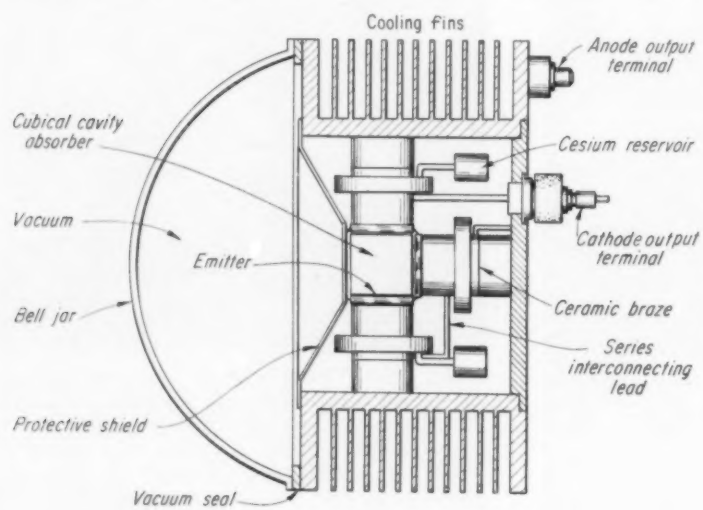
Leaders of these countries are eyeing "exotic" sources of energy, such as solar or wind energy, with an almost mystical faith. Such sources have the advantage of being available wherever needed without expensive transmission equipment.

Their true worth, however, is disputed by some engineers who believe costs are prohibitive, and by many economists who argue that underdeveloped countries can grow faster by developing conventional power plants. United Nations specialists disagree. This fall the UN called a conference in Rome to evaluate the technical status of solar, wind and geothermal energy.

Solar energy dominated the conference. It is adaptable to a variety of applications, large and small, and it is especially appealing to the underdeveloped countries, most of which lie near the tropics where radiation is intense.

Solar devices can be roughly divided into two categories: those that produce moderate heat and those that produce heat appreciably above the boiling point of water.

In devices that operate at moderate temperatures, the heat is used directly to do the job at hand—cook, heat water, heat space, distill fresh water from salt, etc. These are now the most common applications for solar energy.



CAVITY-TYPE THERMIONIC CONVERTER, proposed by George Hatsopoules of MIT and Pierre Brosens, collects its heat from a 5 ft dia solar concentrator. Heat passes through the bell jar vacuum enclosure to the cubical cavity absorber. The absorber is surrounded on five of its 2-cm-long sides by cylindrically shaped thermionic diodes (three of the diodes in the vertical plane are shown here). The heat in the cavity boils electrons off the emitters to the cooler anode surface. Cesium improves the unit's efficiency because it ionizes at the hot surface and prevents build-up of a space-charge barrier that would keep electrons from flowing. Total output of the interconnected diodes is calculated at 300 watts with an over-all efficiency of 17%.

Most of them are still somewhat expensive—a Japanese water heater, with insulated storage tank to keep water hot at night, costs about $80.

The devices that operate at higher temperatures are being used experimentally for industrial processes requiring high temperature and precise control. And they can be used to generate electricity. The latter application is extremely appealing to underdeveloped nations, because the electricity can be used to light villages or run motors for irrigation systems or small industry.

Electricity is obtained from solar energy directly with thermionic or thermoelectric generators, or indirectly by heating water to get steam for a turbine generator. The steam turbine, at present, seems particularly adaptable to individual plants generating from 1 to 5 kw or small community plants generating up to 25 or 50 kw. (The latter would be large enough to pump water and supply electricity for a community of 1000.) Units smaller than 1 kw, it's been found, can't fully exploit the steam that's generated, and larger units need large collectors.

Design of converters

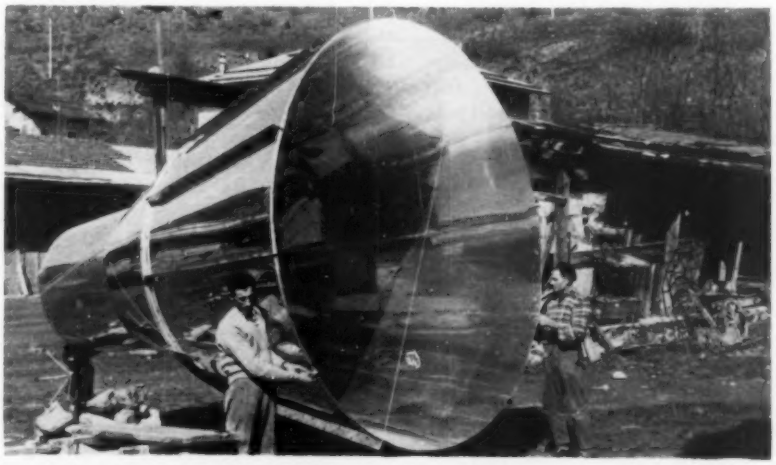
In solar energy devices, the collector generally poses the most difficult design problems—and the higher the operating temperature the more crucial the problem. A good collector absorbs a very high portion of the radiation impinging on it, and loses little of the radiation during transfer to the point of use. (Some designers have tried grooving and corrugating collectors to increase energy absorbing surfaces for a given area, but this gain is canceled by losses at the concentrator.)

Considerable work is underway on collectors that make steam. The National Physical Lab of Israel, an acknowledged leader in developing solar energy, is working on a 300-sq meter reflector that will produce steam through a heat exchanger and high boiling point liquid.

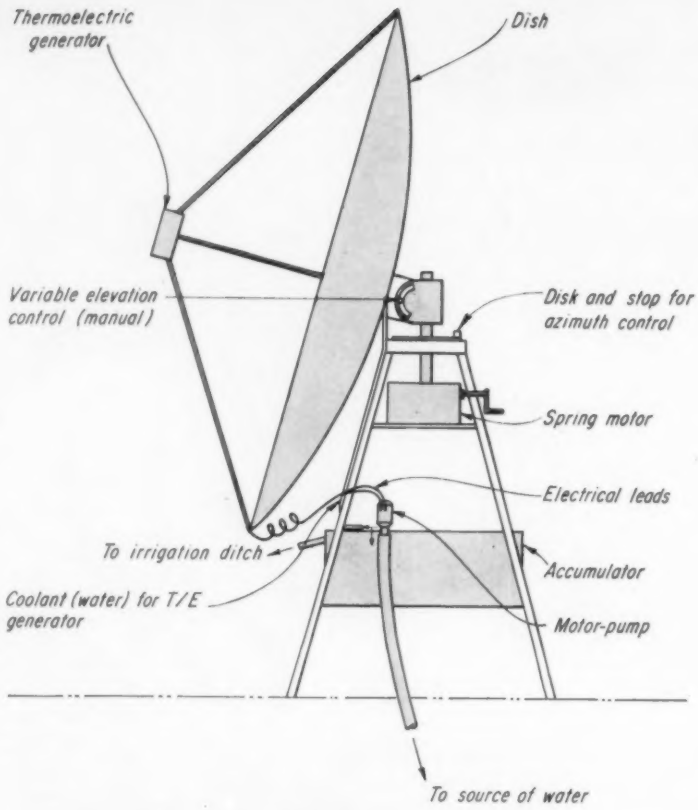
Under direction of Dr H. Tabor, the lab is also working on a solar pond, a promising and inexpensive solution. The pond is 3 to 5 ft deep with a black bottom. It has a high salt concentration (magnesium chloride) that creates density gradients throughout the pond to keep warmer water layered at bottom and cooler water at top. The salt also prevents water from vaporizing and reducing the temperature of the pond.

When the pond is hot enough, its water is moved through a heat exchanger to produce steam. Dr Tabor is now attempting to perfect a way of

SOLAR COOKERS are nearly practical for warm climates now. Local custom is seen as the most formidable obstacle to widespread use. The unit here was developed by Volunteers for International Technical Assistance, an association of US engineers whose avocation is to develop products and give technical aid to underdeveloped countries. The VITA cooker is made of concentric cardboard rings covered with aluminum paper and costs about $1.75.



TRUNCATED CONE COLLECTOR designed in Italy is said to produce high solar concentrations and attain operating temperatures to 5000 C. Its performance is attributed in part to a beehive collector inside that is transparent to incoming radiation but black to re-radiated energy. It may have industrial applications.



THERMOELECTRIC GENERATOR is here used to pump water for an irrigation system. Hot side of the Westinghouse generator operates at about 450 C and the unit produces about 50 watts.

collecting the heat without disturbing the layers.

Direct power generation is still very much in the research stage. A breakthrough within the last five years came with the successful generation of electricity in thermocouples at conversion rate of about 5%. Thermoelectric power generation got powerful impetus from solid-state theory which has provided tailored materials operating over a range of temperatures.

Kurt Katz of Westinghouse Central Research Labs estimates that solar thermoelectric generators producing in the 50-to-1000-w range can now be operated at 7 to 10¢/kw. These costs will drop when the devices go into mass production.

Thermionic converters require higher temperatures than thermocouples (about 1500 C for the hot element) and near-perfect focusing collectors. Basically a thermionic converter is a vacuum diode in which the sun's energy heats a cathode, boiling off electrons that flow to a cooler anode. The problem is that the electrons tend to form a negatively charged cloud around the cathode. To avoid this, anode and cathode are kept very close (about 0.0005 cm) or else positively charged ions such as cesium fill the vacuum tube to act as carriers.

Several thermionic converters were described at Rome, including the Wilson unit developed by General Electric and a German unit. The Wilson converter produces 85 watts at 14-15% efficiency. Its 1.5-in.-dia cathode operates at 1800 C; its anode at 600 C, for power density of 7.5 w/sq cm. The German converter produces power density of 0.8 w/sq cm at 8 to 9% efficiency. Its cathode is sintered barium nickel, operating at 900 to 1000 C.

Solar energy can also be converted into electricity with solar cells, but for some time to come these devices will probably be more practical for space than terrestrial missions. A silicon solar cell panel, supplying 1 kw power, costs between $250,000 and $1 million and weighs between 200 and 400 lb.

The high cost stems in part from the fact that a cell must be grown from a single crystal. At present some work is underway to develop production techniques that do not require the single crystal phase. With cadmium sulfide crystals, it is conceivable that costs could be brought down to $1 to $10 per sq ft. At this level cells using the photovoltaic effect might be attractive for home use in the developed countries of the world.

Solar furnaces

Large solar furnaces, operating at temperatures to 3500 C, have piqued the interest of engineers for some years and units are operating in France, Japan, the US and Russia. They are being used for high temperature experiments on metals and show considerable promise for refining metals and delivering heat to chemical processes.

In refining operations, the furnaces have the advantage of being somewhat freer of pollution than conventional furnaces. The French are using a furnace to refine zirconium for a nuclear reactor with considerable success and the Yugoslavs are reportedly making synthetic minerals in a solar furnace.

Australians report good performance with a 12-ft dia parabolic mirror made of laminated timber with a silver on black coating. This structure is light and rigid. The mirror averaged 80% reflectance over a year.

The Italians see considerable promise in a truncated cone configuration they have developed.

One of the chief handicaps to engineering better solar devices and prescribing suitable working locations for them is the dearth of radiation data. The delegates at Rome agreed that more meteorological stations are needed and that existing stations should coordinate data better to provide information on such items as: intensity and total hours of sunshine, average of direct and diffuse radiation, and levels of radiation over a period of years.

Some of the stations should be located in desert areas. These areas might be developed later on if cheap energy becomes available.

Meteorological stations need better measuring instruments. The engineers will be satisfied with tolerances of ±10%, but scientists are holding out for tolerances of ±3%.

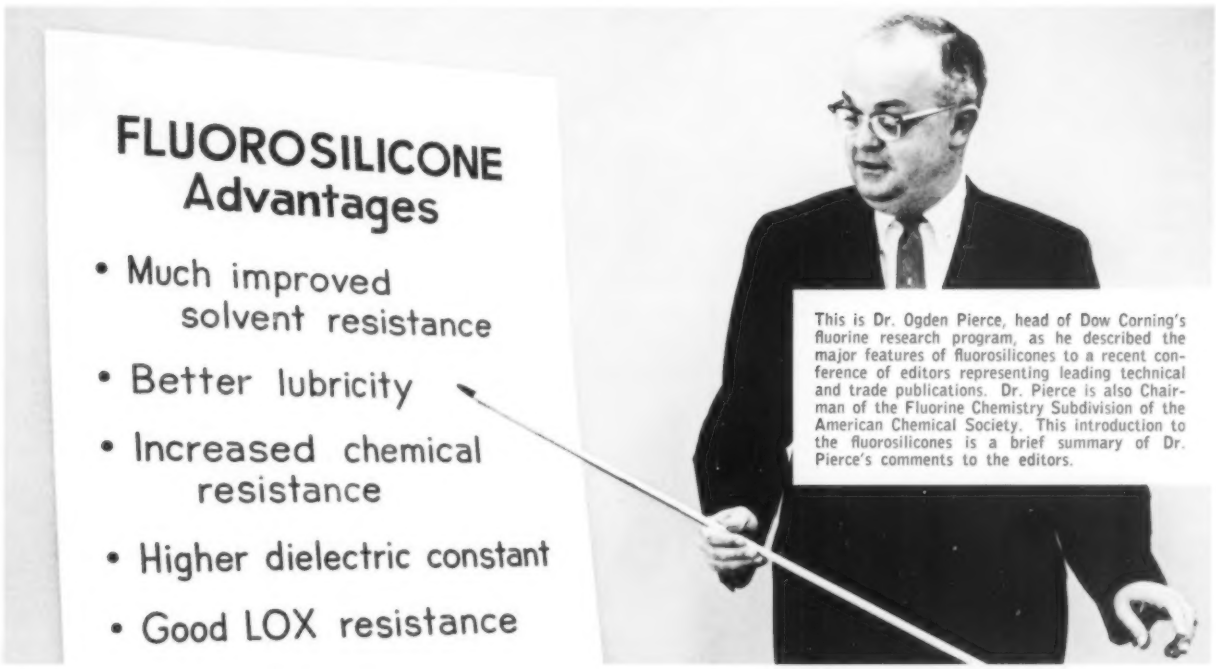
CIRCLE 241 ON READER SERVICE CARD→

first in silicones

Dow Corning

SILICONE NEWS

for design and development engineers · No. 88



This is Dr. Ogden Pierce, head of Dow Corning's fluorine research program, as he described the major features of fluorosilicones to a recent conference of editors representing leading technical and trade publications. Dr. Pierce is also Chairman of the Fluorine Chemistry Subdivision of the American Chemical Society. This introduction to the fluorosilicones is a brief summary of Dr. Pierce's comments to the editors.

Meet the FLUOROSILICONES

The fluorosilicones are a new family of semi-inorganic polymers that offer a high order of solvent resistance, markedly improved lubricity, and all the more desired properties of standard silicone materials.

Chemically, most commercial silicones have methyl groups attached to the siloxane polymer. Fluorosilicones are produced by substituting fluoroalkyl groups for most of the methyl groups.

Fluorosilicones are available in four different physical forms: fluids, greases, compounds and rubbers. While the rubber-like materials were first introduced five years ago, the other fluorosilicones are completely new products.

They are, however, already advanced beyond the "experimental" stage, and pilot plant quantities are being produced for several military and industrial applications in which these new materials have proved to be effective and economical.

Suggested Uses

Greases — as all-temperature lubricants that provide lasting lubrication in the presence of solvents and chemicals.

Fluids—as defoamers of solvents and oils; as lubricants, damping media, flotation fluids and plasticizers in areas where solvent resistance is essential.

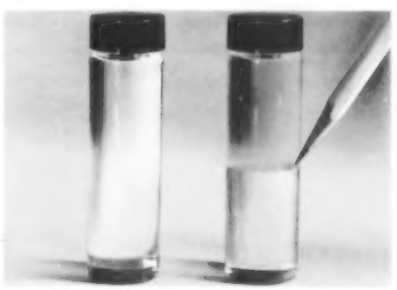
Compounds—as greaselike lubricants for valves, rubber O-rings, grommets and mounts in contact with liquid fuels, solvents and chemicals.

Rubbers—demonstrate outstanding resistance to solvents, jet fuels, oils and fluids over an operating temperature range of —80 to 500 F.

Solvent resistance

Fluorosilicone fluids are insoluble in most solvents (except the ketones and esters) and are incompatible with most petroleum oils.

In demonstration at right, both vials had been half-filled with perchloroethylene. A standard silicone fluid was then added to vial on left, and one of the new fluorosilicone fluids was added to vial on the right. You see both vials a few moments after they were well shaken and then allowed to stand at rest. Note how the standard silicone fluid has been completely dissolved by the perchloroethylene, while the fluorosilicone fluid separated quickly and completely as indicated by the meniscus in the vial at right.



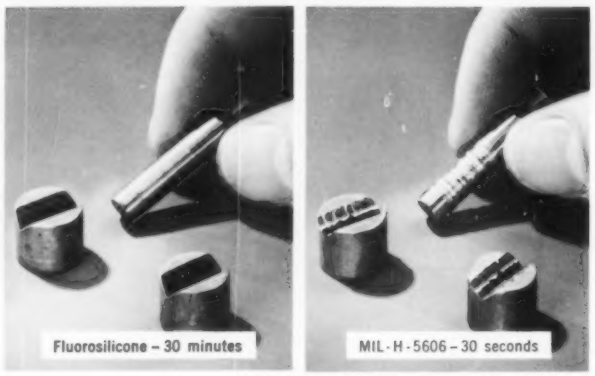
For technical information about all fluorosilicones, use coupon on next page or circle reference number **241** on reader service card

Meet the FLUOROSILICONES

Improved lubricity

That fluorosilicones have exceptional lubricity has been verified by both Falex tests and field experience.

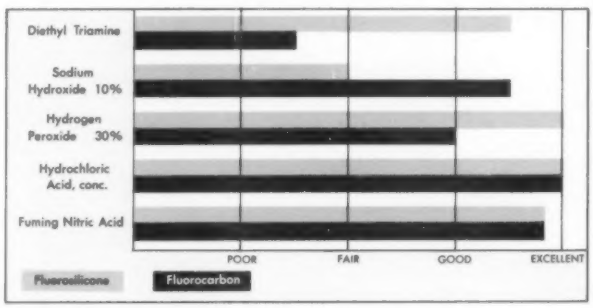
In the Falex test, a small shaft under load is rotated between two steel vee-blocks while immersed in the test lubricant. In the left photo you see shaft and vee-blocks tested in one of the new fluorosilicone fluids. Test time was 30 minutes; test load — 350 pounds. The shaft and blocks in the right hand photo were tested in standard MIL-H-5606 Hydraulic type oil. Test load was 350 pounds; however, test time was only *30 seconds!* Note the fluorosilicone set shows little scoring and wear even after 30 minutes testing.



Chemical resistance

The good chemical resistance of fluorosilicones is illustrated by the bar graph at right.

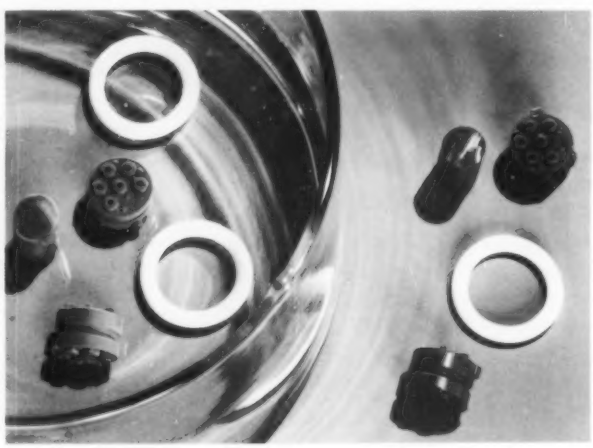
In determining these ratings, glass slides coated with a Dow Corning fluorosilicone compound were immersed to *half* the coating depth for 16 hours in diethyl triamine; 30% hydrogen peroxide; fuming nitric acid; concentrated hydrochloric acid, and 10% sodium hydroxide. Only the 10% sodium hydroxide exhibited any appreciable effect on the fluorosilicone compound.



Elastomers, too

Fluorosilicone rubbers, named Silastic® LS, have thoroughly proved their effectiveness in a variety of military and industrial applications requiring solvent-resistance, inertness and serviceability at both high and low temperatures. A look at the properties will explain why fluorosilicone rubbers have enjoyed rapid acceptance.

PROPERTIES	
Hardness, Shore A	50-65
Tensile Strength, psi	800-1000
Elongation, percent	150-170
Serviceable Temperature Range	—80 to 500 F
Fuel Resistance (JP-4), percent change after 30 days immersion	
Durometer	—5
Tensile Strength	—31
Volume	+10
Weather Resistance, after 31 months (3549 sun hours) at Florida Test Station — no visible effect.	



Silastic LS, fluorosilicone rubber parts at left show negligible swell after prolonged immersion in JP-4 fuel. Compare size with identical parts at right which were not immersed in the fuel.

Dow Corning Corporation, Dept. 5223, Midland, Michigan

Please send me technical data about all fluorosilicones

NAME_____

TITLE_____

COMPANY_____

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CITY_____ ZONE____ STATE_____

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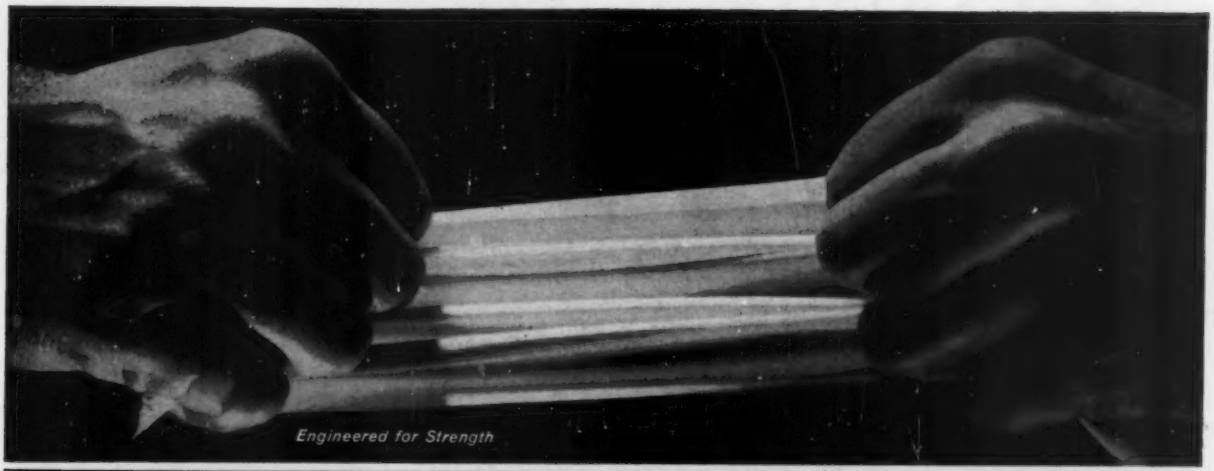
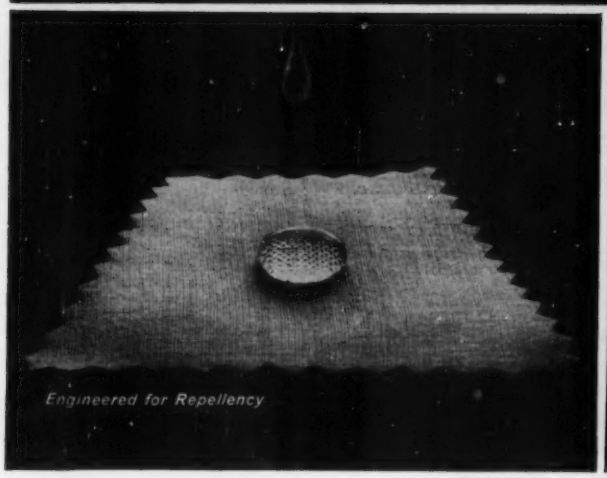
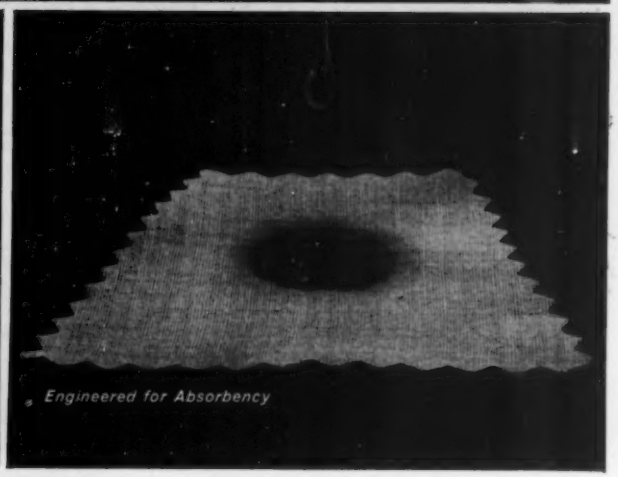
For technical information about all fluorosilicones, use coupon on this page or circle reference number 241 on reader service card

An example of Avisco Rayons in Industry







There's an application for Avisco® rayon in your business

The big news in industry today is the increasing use of Avisco rayon fibers. Versatility is the reason. Avisco rayon can be custom engineered to meet your end-use requirements.

Need strength? Avisco rayon fibers add backbone, tensile and flex life to beltings, burst strength to hoses, tensile and tear strength to coated fabrics and laminated paper, film and foil.

Need absorbency (or repellency)? Avisco rayon fibers are used extensively in medical and hygienic products.

Need superior filtration? Avisco rayon fibers are produced in a wide range of precise micron diameters to control porosity and improve efficiency.

Whatever you make, there's a way you can save time and money with Avisco rayon fibers engineered to your specific requirements. Find out now.

QUICK REPLY COUPON 66

Industrial Merchandising Division
American Viscose Corporation
350 Fifth Avenue, New York 1, N.Y.

Please contact me about Avisco Rayons for use in the following application:_____

Name_____

Company_____

Address_____

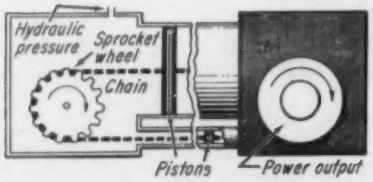
City_____ Zone____ State_____

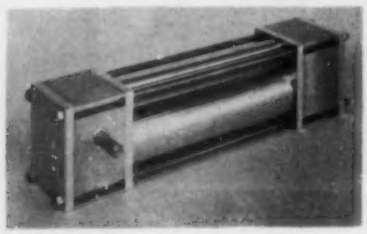
AVISCO RAYON

AMERICAN VISCOSE CORPORATION, 350 Fifth Avenue, New York 1, N. Y.

CIRCLE 129 ON READER SERVICE CARD 129

NEW COMPONENTS



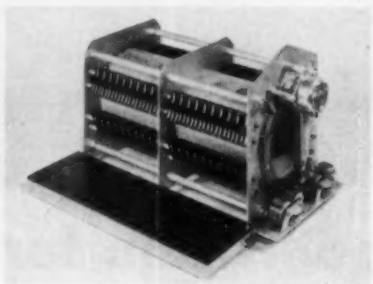


Rotary actuator . . .
for converting hydraulic power into uniform rotational motion, performs a complete cycle within its own length, with no shafts or piston rods to extend. Thus, unit performs equivalent function in less than half the length required by conventional cylinder-operated rack-and-pinion actuator. Provides as many turns as desired, with constant torque throughout, and because power is derived from motion of a self-centering piston rigidly coupled to a continuous chain, unit is without backlash and sensitive to minute changes in flow of actuating fluid. Fluid introduced under pressure at one port exerts unequal forces on primary and secondary pistons as a result of piston area differential. Force at primary piston, being greater, causes clockwise rotation of drive shaft. Reversing direction of rotation is accomplished by introducing fluid at opposite port. Piston is Teflon-sealed and can be used without lubrication. Operating pressure is up to 150 psi in standard models (can be supplied for pressures from vacuum to several thousand psi). Speeds of 1 revolution per wk or less to several thousand rpm can be had, while output torque in 14 sizes ranges from 10 to 30,000 in.-lb at nominal pressure of 100 psi. Max hp delivered from single unit is more than 100 hp (by ganging units on single shaft, hp can be increased in increments of 100). Standard model provides 90° rotation. Applications up to 50 turns are generally provided through internal gear drives and continuous stepping motion is accomplished through internal clutches. Priced from $25 to $400, with delivery in 3 to 4 wk. **Graham Engineering Co, 714 Loma Verde Ave., Palo Alto, Calif.**

Circle 300 on Reader Service Card

Needle thrust bearings . . .
have glass fiber-filled nylon separators that reportedly offer less sliding friction, longer wear and higher operating speed than interchangeable sizes of all-steel needle thrust bearings. Rollers, made of SAE 50100 steel hardened to Rc 60 min, are held to 0.0002-in. tolerance on diameter for uniform load distribution and max capacity. No machining is done on separators after molding, and rollers are snapped into separator pockets to make self-contained assembly. Bearings reportedly perform under high loads and oil temperatures exceeding 300 F and speeds up to 3000 rpm with oil lubrication. Needle roller thickness is standardized at 0.0781 in. Sizes from stock have nominal IDs of 1.114 and 1.255 in. and nominal ODs of 1.800 and 1.917 in., respectively. **Kaydon Engineering Corp, Muskegon, Mich.**

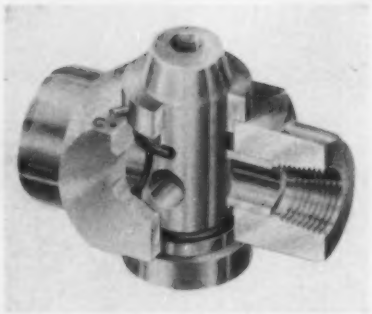
Circle 301 on Reader Service Card



Program controller . . .
is high-speed unit in which program drum is indexed at rate of three steps per sec by a rotary solenoid. Switches 80 circuits in 100 steps per cycle. Standard snap-action SPDT switches are rated 15 amp on 125 v ac. Roller actuator is lifted by head self-tapping screw inserted in selected hole in steel drum. Rectifier is supplied to operate rotary solenoid from 115-v ac pulses. Plate in front holds terminal blocks for switches. Measures 9 x 9 x 20 in., but also available with 100 circuits with increased over-all length and 150 steps per cycle with increased drum diameter. **Cobar Machine Tool Co, 16 Rainbow Trail, Mountain Lakes, NJ.**

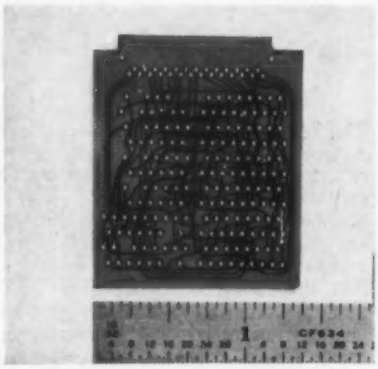
Circle 302 on Reader Service Card

Rotary valve . . .
is O-ring sealed. When pressure is applied from one side of valve, bore sealing O-ring mounted on that insert expands slightly circumferentially,



and in doing so its cross section is slightly reduced, allowing a leakage into the annular space. Leakage builds up a pressure in the annular space which forces other bore sealing O-ring onto its insert and makes a pressure-tight seal. Pressure in annular space also forces gland sealing O-rings outward against top and bottom collars to make pressure-tight joints. Bore sealing rings are fitted to both inserts to make valve seal for both directions of flow and to balance side thrust. Unit, which needs no lubrication, can be used up to 5000 psi and in temperature range from −60 to 400 F. Available in ¼- to 3-in. sizes, screwed and flanged. **Atlantic Aviation Corp, Sub of Aero Industries Inc, 230 S Reading Ave, Boyertown, Penna.**

Circle 303 on Reader Service Card



Multilayered printed circuits . . .
which have layer-to-layer interconnection by means of landless plated-through holes, now are available in miniaturized versions on a pilot production basis. Technique permits printed circuits to be designed and manufactured in many layers and laminated together under heat and pressure to produce circuit panels with great system flexibility. One re-

continued, page 133

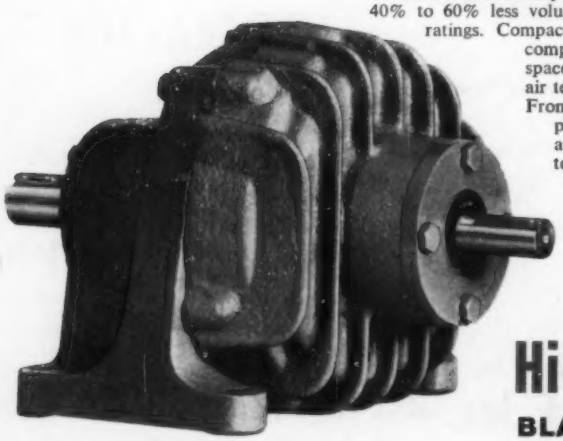
FRY & CO. PICKS HI-RANGE REDUCTION DRIVE FOR ITS "CUSTOMER ADVANTAGES"

"We selected Hi-Range Reduction Drives because they offer our customers low maintenance, economical price and compactness," reports Fry & Co., Inc., Denver, whose FLOmaster automatic self-claim baggage handling equipment is installed for United Air Lines at the new Los Angeles International Airport. There, FLOmaster has two conveyors, 160' and 126' long, both using a Hi-Range Reduction Drive. Fry & Co. has used Hi-Range Drives for over a year—operating in newer air terminals all over the world.

The cycloid principle enables Hi-Range Drives to offer you many unique advantages. Standard ratios of 15-1 up through 174-1 are available IN A SINGLE STAGE OF REDUCTION. Input and output shafts are on the same axis. Units are compact—40% to 60% less volume and weight than other types of reducers of comparable ratings. Compactness of Hi-Range Drives lets Fry & Co. fabricate a more compact conveyor. In fact, use of this unit alone saves enough floor space to accommodate another passenger—an important factor with air terminals!

From a cost standpoint, Hi-Range Drives are equal to or lower in price, when compared to conventional reducers of equal ratio and torque. On this basis, Fry & Co. reports Hi-Range Drives to cost 30% to 50% less. And they're more efficient, particularly in the higher ratios.

Find out how Hi-Range Reduction Drives can save you money... how you can pass the plus-factors of these units on to your customers! **Write for New Master Catalog RD-61.**



CYCLOIDAL
Hi-Range Reduction Drives

BLACK TOOL, INC. 1924 S. Navajo St. • Denver 23, Colorado

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Helios *Versatile • Accurate • Time-saving and Easy-to-Read*

PRECISION CALIPERS

NEW! MODEL TUR68E
WITH ADJUSTABLE TOLERANCE DIAL

from $41.85 Includes Wooden Case

Model UR 68E with Fixed Dial $38.85

- GUARANTEED ACCURACY TO 0.001"
- ELIMINATES READING ERRORS
- HARDENED THROUGHOUT
- MEASURING SURFACES GROUND & LAPPED
- SIZES 6", 8", 10"; IMMEDIATE DELIVERY
- STAINLESS STEEL MODELS AT SMALL ADDITIONAL COST

VERNIER Model 1050EK5

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- IMMEDIATE DELIVERY
- GUARANTEED ACCURACY TO 0.001"
- STAINLESS STEEL
- HARDENED THROUGHOUT

DIAL CALIPER Model UR53E

from 36.15 Includes Wooden Case

- SIZE: 5 INCHES
- GUARANTEED ACCURACY TO 0.001"
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- IMMEDIATE DELIVERY
- AVAILABLE WITH ADJUSTABLE TOLERANCE DIAL, MODEL TUR53E, $3 EXTRA.
- STAINLESS STEEL MODELS AT SMALL ADDITIONAL COST

Write for NEW Catalog of Over 100 Helios Precision Measuring Instruments

SCHNORR DISC SPRINGS

Eliminate Fatigue, Settling, Creeping

Schnorr disc springs protect the gears of this streamliner from torque overload

SCHNORR SPRINGS PROVIDE UNLIMITED LIFE!
Check these exclusive features:

- **ADJUSTMENT—** SCHNORR SPRINGS provide different pressure and deflection with exacting adjustment. ALL FROM ONE SIZE.
- **COMPACTNESS—** Great power is concentrated in a very small space.
- **ABSORPTION—** Dampens impacts, and minimizes after-oscillation.
- **VERSATILITY—** SCHNORR SPRINGS can be easily adjusted to provide a varied range of spring pressures and deflections. The springs may also be stacked to provide multiple force.
- **SPECIALIZATION** SCHNORR DISC SPRINGS may be obtained in a variety of sizes for specialized tasks. MODEL K is especially adaptable to eliminate noise and play in ball bearings.

Further Information and Literature on SCHNORR DISC SPRINGS is available from:
Exclusive Distributor: KARL A. NEISE, INC.

Helios **Precision Measurement Between Surfaces NOT ON THE SAME PLANE**

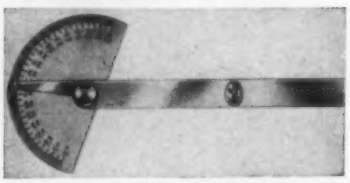
SWING JAW CALIPERS

from $33.90 (Less Case)

- Model SCH1053 illustrated. Sizes 6", 8"
- Guaranteed Accuracy to 0.001"
- Measuring Range 4¾" and 8"
- Immediate Delivery

Helios **HIGHEST PRECISION**
Celebrating 50 Years of Measuring

PROTRACTORS



Comparable to others that Sell at 3 Times More! **Only $4.40**

Made of Fine Machine Steel. Dull Chromed Scales. Choice of Semi-Circular or Rectangular Model 51508. 6" long; 3¼" diameter. Immediate delivery.

NEISE MODERN TOOLS *U. S. Representative* **KARL A. NEISE, Inc.** 406 4th AVENUE, NEW YORK 16, N. Y.—MU 3-0481

duced-in-size circuit measures 1.6 x 1.4 x 0.050 in. and has three circuit layers. Includes 205 plated-through holes, 0.013 in. dia. Hole-to-hole distances are 0.050 and 0.066 in. Conductor width is 0.010 in. Miniaturized circuits can be had with up to six individual circuit layers. In production quantities, they are priced from approx $10 to $50, with delivery in 4 to 5 wk. **Photocircuits Corp, Glen Cove, NY.**

Circle 304 on Reader Service Card

Integral cylinder valve . . .
is self-contained and self-regulating unit which operates without outside power source or control system. Suitable for ultra-high pressure stop valves, flow control, over- and under-pressure relief, pressure reducing and back pressure control. Handles wide range of fluids, including high viscosity types, in split-second operation under any pressure. Said to be highly resistant to abrasion and erosion and to offer straight-through, non-turbulent flow, wide rangeability and self-purging action. **General Kinetics Corp, 197 S Van Brunt St, Englewood, NJ.**

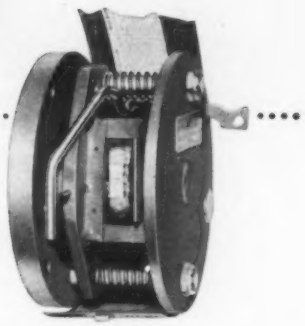
Circle 305 on Reader Service Card

Indexing drive . . .
for adaptation to cycling precision conveyors, transfer chassis and dial indexing machines, has torque range of 25,000 in.-lb. Cam and roller internal components provide modified trapezoid acceleration pattern for smooth and shockless indexing. Cams, made of hardened and ground tool steel, provide indexing accuracy within 0.001 in. on a 12-in.-dia sprocket or dial. In addition, preloaded roller bearing followers have zero backlash in dwell position. Available with output shaft angular movements of from 4 to 24 stops and indexing periods in 90, 120, 180 and 270° to permit selective cycle timing

continued, page 135

db LET DINGS DO IT!

NEW COMPACT BRAKE



WRAP AROUND COVER
No extra space needed for cover removal. Ideal for confined spaces.

No special motor design. Fits all motors without disassembly.

The new Dings "Universal" Series 60 — 1½ and 3 lb. ft. torque Compact Brake offers all the advantages of Dings standard brakes *plus* the economy and convenience of easy, fast attachment and easy access. Here's assurance of an attractively compact, brake-motor package!

For NEMA motor frames 56C, 66C, 182C & 184C (all manufacturers). For continuous or intermittent service.

1. Slide brake on the motor shaft.
2. Bolt to standard NEMA "C" flange mounting.
3. Knockout plug provided for Thru-Shaft feature on all units.

Write for further details.
Ask for BULLETIN BK4709.

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DINGS BRAKES, INC.
A SUBSIDIARY OF DINGS MAGNETIC SEPARATOR CO.
4715 West Electric Avenue
Milwaukee 49, Wisconsin

DB-361

CIRCLE 133 ON READER SERVICE CARD

SAVE SPACE, SAVE WEIGHT,

SAVE MONEY!

Dyna V

There's a *difference*, as you can see! The 10-groove D-section sheave in the foreground is replaced with the narrow 8-groove 5-V Dyna-V sheave on the line shaft. *Same power*, in a far more compact installation, with a $477 difference in price. And big future savings in belt replacement costs!

Everyone is going Dyna-V! Thousands of installations reveal that Dyna-V performance is *even better* than promised when we first introduced this new compact drive. In medium and high horsepower ranges, savings go as high as 30%!

Dyna-V can handle 3 times as much power in the same space. Dyna-V Sheaves decrease shaft overhang, increase bearing life. And Dyna-V Belts possess *all* premium qualities. Conditions requiring static conductivity or resistance to oil, moisture and heat are met by Dyna-V's one grade—the finest. Ask your Dodge Distributor, or write us for complete drive bulletin. Dyna-V Drives are available for capacities from 1 to 1500 hp.

Dodge Manufacturing Corporation, 1200 Union St., Mishawaka, Ind.

The Products with the Pluses...

DODGE

of Mishawaka, Ind.

CALL THE TRANSMISSIONEER, your local Dodge Distributor. Look under "Dodge Transmissioneer" in the *white* pages of your phone book. Factory trained by Dodge, he can give you valuable assistance.

of index and dwell. Double-extended input cam-shaft allows synchronization with tooling, actuators and cam-switching interlocks. Cam-shaft also can be used to actuate shot-pin into index plate mechanically during dwell period. This eliminates need for extra electrical and hydraulic controls. Output shaft capacity up to 5½ in. dia is available with appropriate bearing size for direct mounting of a sprocket or rotary dial. **Visi-Trol Engineering Co, 12720 Burt Rd, Detroit 23.**

Circle 306 on Reader Service Card

Carbon potentiometer . . .
is a square-shape unit comprising an element that has high-temperature carbon deposited on an inert and moistureproof ceramic base. Said to provide more temperature and moisture stability than other deposited carbon potentiometers. Resistance range is 20 k to 1 meg; power rating, 0.50 w at 122 F; electrical rotation, 25 turns nominal; and operating temperatures, −85 to 302 F. Measures ½ x ½ x $\frac{5}{16}$ in. and weighs approx 0.1 oz. Priced at approx $5.50 in production quantities. **Trimpot Div, Bourns Inc, 6135 Magnolia Ave, Riverside, Calif.**

Circle 307 on Reader Service Card

Relays and contactors . . .
are 30-amp units for non-inductive loads. Reported features include quiet operation, wiping contacts, laminated frame operators and high contact pressure. Units are contact rated at 30 amp, 250 v ac and may be applied continuously up to full rating, open or enclosed, with conservative temperature rises. Prices range from $27 to $35. **Automatic Switch Co, Florham Park, NJ.**

Circle 308 on Reader Service Card

Linear accelerometer . . .
is said to provide highest frequency response available in a strain gage accelerometer, made possible by use of

continued, page 140

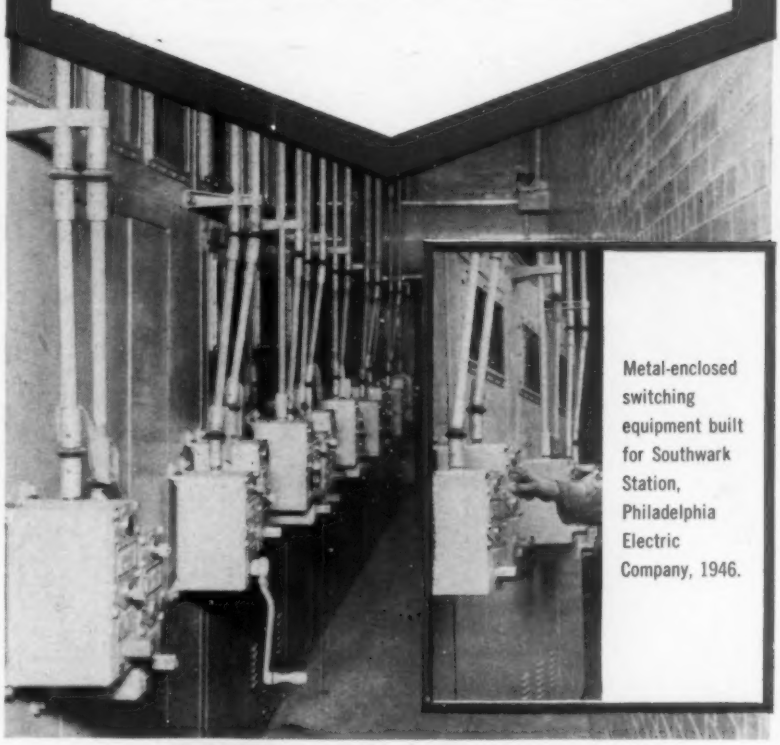
APEX UNIVERSAL JOINTS GIVE YOU COMPLETE DESIGN FLEXIBILITY

I-T-E Circuit Breaker Company selected Apex universal joints because "they offer full flexibility in designing various types of off-center switch operating mechanisms".

Used for indoor and outdoor service under varying temperatures and humidity conditions, Apex *covered* universal joints "solved all our problems for a very compact, easily installed operating shaft".

Working out a dependable, efficient drive-line design is so much easier when you specify Apex universal joints. Standard sizes, ¼" to 4" diameters, covered or uncovered. Full range of hub types. On special applications, send sketch or print for prompt recommendations and quotation.

PHOTOS COURTESY I-T-E CIRCUIT BREAKER COMPANY, GREENSBURG, PENNA.



Metal-enclosed switching equipment built for Southwark Station, Philadelphia Electric Company, 1946.

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or write, on your company letterhead please, for Catalog 28 and Data Sheet.

THE APEX MACHINE & TOOL CO.
DAYTON 2, OHIO

Gates advanced design drive **SAVES** money, space, weight on every machine you make

The machines you design can be more compact, lighter weight and lower cost by using Gates Super HC High Capacity V-Belt Drives. Because of exclusive construction features, this high capacity drive — industry's first — can often cut in half the space formerly required for a V-belt drive. Gates Super HC Drive is your best assurance that your power transmission unit will not soon become obsolete.

The Gates Field Engineer near you is an experienced, fully-qualified drive design expert. Contact him for drive design help.

The Gates Rubber Company, Denver 17, Colorado

Gates

Building the future on 50 years of progress

Gates Super HC V-Belt Drives

BP-9

Lamb Thinking on Universal Motors for a unique actuator application

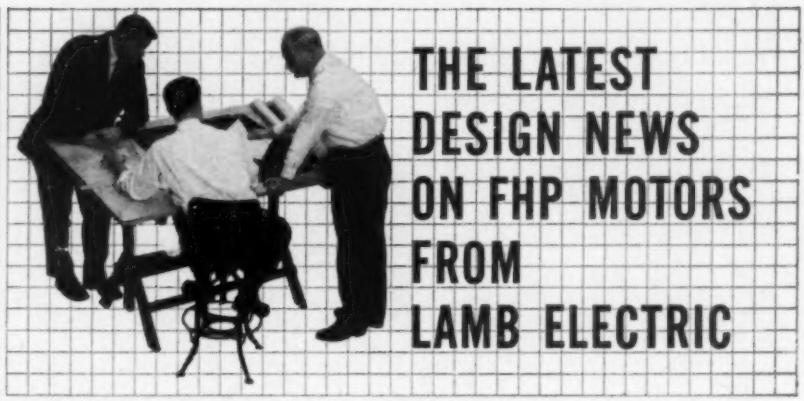
Here's what Lamb Electric designed into these motors:

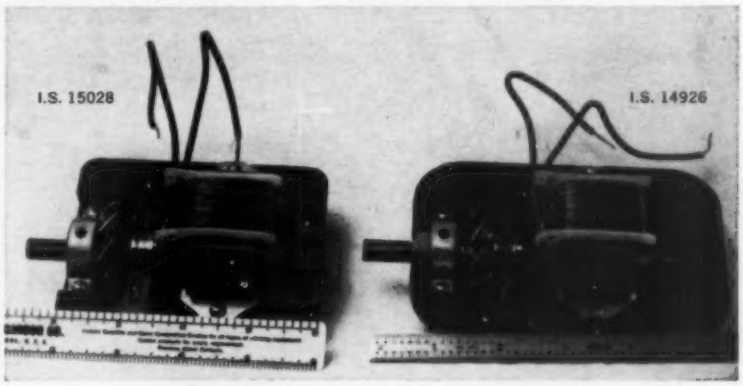
In order to obtain the required speed and torques and retain the most economical and smallest package, a combination worm and spur gear reduction was used. Also, because of the peculiar space limitations in the application, special design considerations had to be given to the gear ratios and mechanical layout of the package.

In the initial stages of the design a motor was provided which met the specified speed and torque requirements, however it was soon discovered that this design overheated rapidly. Analysis of the first prototype tests showed that the load cycle had a particularly high torque peak for a very short duration. The motor was designed to supply this amount of torque near its stalled speed. It was found that by taking advantage of the accelerating rate and starting torque of a universal motor, the motor accelerated quickly enough to provide sufficient inertial energy to complete the duty cycle. This enabled the engineers to redesign for a lower peak horsepower output and obtain reasonable operating temperatures, thus producing the minimum size package consistent with the torque and temperature requirements.

The application was such that severe shock loading was encountered at a certain point in the duty cycle. In order to make mechanical construction that would withstand this service, ductile iron castings were furnished and special consideration had to be given to the overhung moment of the motor-gear unit to insure against damage due to vibration. Special bearings had to be used in this service because Brinnelling would occur on normal ball bearings under the severe service encountered. Lubrication is generally a problem under this short duty cycle, therefore, special consideration had to be given to insure that the lubricant protected the wearing surfaces at all times.

This is just a short example of Lamb at work . . . if you have a motor problem, let us help you with it. This is our business. Write: Lamb Electric, Kent, Ohio, and we'll have a Lamb District Engineer call on you to open preliminary discussion of your problem.





New Lamb motors represent advancements in small universal motor design

New design combines high quality and long life with relatively low manufacturing costs

Initially, the I.S. 15028 and companion motor I.S. 14926 were designed for powering rug agitators on a well-known line of canister-type vacuum cleaners. Now, many future appliance applications have been visualized. The range of ratings possible with this design (as high as 1/10 H.P. at 12000 RPM or ⅛ H.P. at 15000 RPM) makes this motor ideally suited for many motor powered domestic applications.

Some of the novel features of this motor project were:

The housing is a one-piece simple phenolic molding. It is designed in a half shell form in such a way that the motor bearings and other components can be held in accurate relationship with an unmachined housing.

The half shell housing of the motor is designed to mate with a corresponding opening on the customer's device to complete the motor enclosure. When a free standing motor is desired, this upper enclosure can be a simple stamping.

The I.S. 15028 motor was designed with a sleeve and a ball bearing. However, on other versions of this motor, either sleeve or ball bearings or a combination can be used at only a low tooling expense through use of easily interchanged inserts in the housing mold cavity.

The sleeve bearing as used in this design takes full advantage of the economics possible with the half shell motor design. The full-spherical shaped self-aligning type of sintered bearing is mounted directly in a semi-spherical recess in the housing. A spring clip presses against the top of the bearing to secure it in place while at the same time permitting self-alignment movement. Life-time lubrication is provided by an oil soaked felt strip located beneath the bearing. There are other features worth noting in this unique design problem. For further particulars, write to Lamb Electric Co., Kent, Ohio.

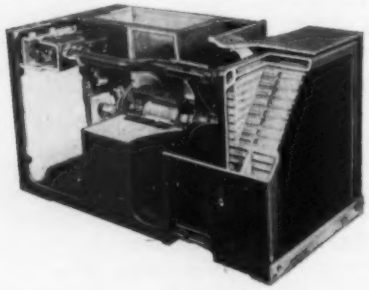
CIRCLE 137 ON READER SERVICE CARD 137

THE HEAT IS OFF THE B-52

General Electric silicone dielectric fluids keep electronic gear running cool and efficiently – indefinitely

We've taken the heat out of the B-52. We've done the same for the B-47, B-57, and B-66. We can do the same for you.

Shown here is the HALLICRAFTERS Company heat exchanger, HD-406, now being used to cool electronic counter measures equipment in all of the above Air Force bombers.



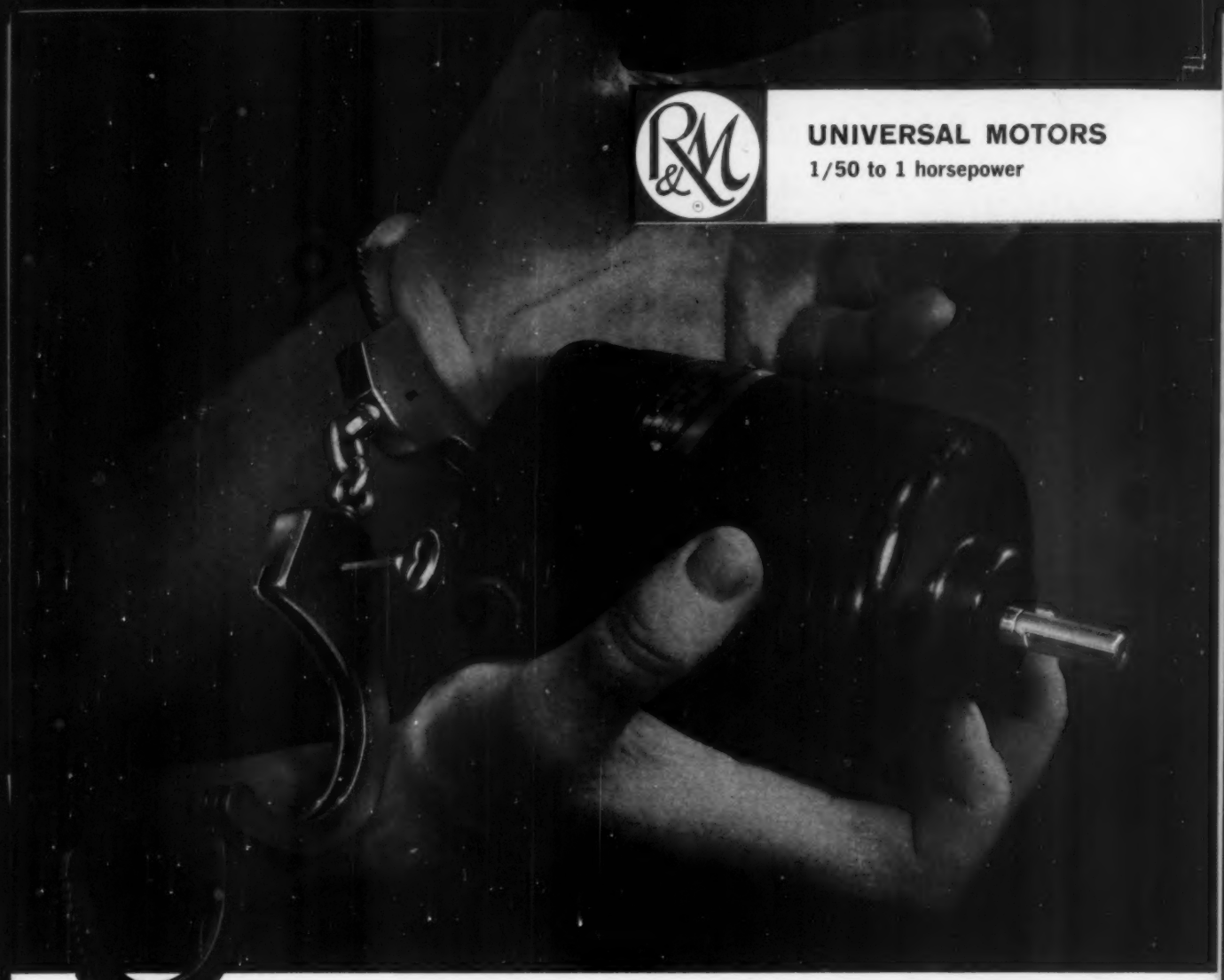
G-E silicone dielectric fluid SF-97 is used as a coolant and dielectric in this equipment. This coolant has excellent electrical properties, and eliminates pressurization requirements at high altitudes.

SF-97 also maintains *consistent* viscosity: requires minimum pumping power. It operates over a wide temperature range, (down to −65°F), cooling reliably and efficiently. Possesses excellent thermal and oxidative stability.

G-E silicone dielectric fluids are used in capacitors, pulse transformers, in air-borne and land-based radar units, and in many systems where heat transfer and dielectric properties are necessary.

If you need the heat taken off your electronic components, get the full story on G-E silicone dielectric fluids. Write: General Electric Company, Silicone Products Department, Section A1162, Waterford, N. Y.

GENERAL ELECTRIC



UNIVERSAL MOTORS
1/50 to 1 horsepower

NEW DESIGN FREEDOM FOR YOU...

R&M unshackles your designers' hands by providing a wide range of Universal Motors for powering portable tools, household appliances, business machines and many other products. R&M Universals are available 1/50 to 1 HP, AC and DC operation, fixed or reversible rotation, open or totally enclosed, with rigid bases or end mounting. Motors feature high operating speed, high starting torque, adaptability to speed control, and light weight per horsepower. Quality materials, skillful engineering and precision manufacture assure long, dependable life and quiet, vibrationless operation. Besides standard ratings, many special designs are now engineered and tested due to past custom-designing . . . or R&M will custom-design a motor for your specific application. Write today for R&M Bulletin 444-PRE

ROBBINS & MYERS, INC., Springfield, Ohio

Fractional and Integral HP Electric Motors • Electric Hoists and Overhead Traveling Cranes • Moyno® Industrial Pumps
Propellair® Industrial Fans • R & M-Hunter Fans and Electric Heat • Trade-Wind Range Hoods and Ventilators
Subsidiary companies at: Memphis, Tenn., Pico Rivera, Calif., Brantford, Ontario.

CIRCLE 139 ON READER SERVICE CARD

One word explains the popularity of these switches...

Dependability!

Denison LOXSWITCH Limit Switches operate with the dependability of Old Faithful. Oil- and dust-tight features, superior electrical characteristics and mechanical design result in three to five times longer life than comparable switches.

L100W HEAVY DUTY LIMIT SWITCH

- 45 CIRCUIT ARRANGEMENTS.
- LONGEST CONTACT LIFE due to lowest impact of 2.5 grams and minimum "bounce".
- WATER-, DUST- AND OIL-TIGHT, NEMA 12.
- ONLY FOUR MOVING PARTS. Longer life, easier to maintain.
- 70° SAFETY OVERTRAVEL without use of extra springs or cams.
- OVER 150 LEVER STYLES.

MODEL M PRECISION LIMIT SWITCH

- LONG MECHANICAL LIFE nylon latch mechanism.
- 600 VOLT INDUSTRIAL CONTROL RATING.
- COMPLETELY ISOLATED CIRCUITS.
- 6° TRIP DIFFERENTIAL, 50° overtravel in both directions.
- PRECISION REPEATABILITY ± .001".
- WATER-, OIL-, DUST-TIGHT – NEMA 12.
- FULLY INTERCHANGEABLE with thousands of existing layouts.

BOTH MODELS AVAILABLE WITH PLUG-IN CONVENIENCE

Write for literature describing our complete line.

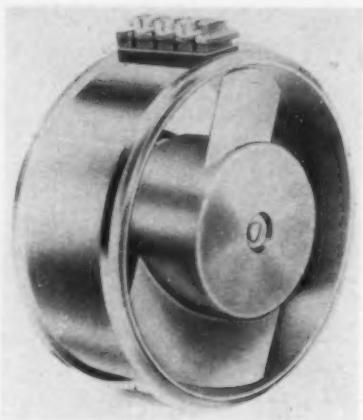
Address R. B. DENISON MFG. CO., 386 Broadway, Bedford, Ohio

DENISON LOXSWITCH®

*Wire with **LOXSWITCH** and you wire for good!*

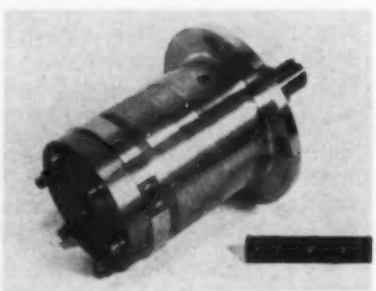
a "gas damping" technique. In a ±100-g range, unit's frequency response is flat from static up to 2100 cps. Ranges are from ±7.5 through ±250 g. Relatively constant damping is provided from −65 to 250 F without need for a heater jacket. Excitation is 5 v dc or ac (rms) through carrier frequencies. Full scale open circuit output is approx ±20 milliv at 5 v. Weighs approx 4 oz. **Statham Instruments Inc, 12401 W Olympic Blvd, Los Angeles 64.**

Circle 309 on Reader Service Card



"Biscuit-thin" tubeaxial fan . . . delivers 110 cfm at 50,000 ft. Input is 200 v, 3 phase, 400 cps, with 19-w input power and current of 0.07 amp at 12,500 rpm. Standard operating range is −67 to 257 F. Rated for continuous duty, the 1¼-in. thick fan incorporates large diameter bearings and is supplied with screw type terminal and servo clamp mount. From stock. **IMC Magnetics Corp, Eastern Div, 570 Main St, Westbury, LI, NY.**

Circle 310 on Reader Service Card



H_2O_2 pumps . . . that also handle other liquid monopropellants and fuels, deliver from 0.1 to 20 gpm at pressures up to 3000 psi. Design is a multicylinder swashplate

continued, page 143

Get to the heart of your problem with "Pump Engineering"

Let Marlow take the pumping "headache" out of your design department. It's not just a dream but a proved fact that a custom-engineered Marlow can put efficiency into your product and give you a definite selling advantage over your competition. Marlow's Pump Engineering has done just that for Original Equipment Manufacturers in many diversified industries.

Modern, automated, manufacturing and engineering facilities enable Marlow to produce efficient, reliable, custom designed Self-Priming, Centrifugal, Straight Centrifugal, Diaphragm and Plunger Pumps... at mass production prices.

Get in touch with us immediately. Write, wire or call and, in no time at all, a Marlow Field Engineer will be at your plant, ready and able to help you plan or design. There is no obligation and—it costs you nothing to find out.

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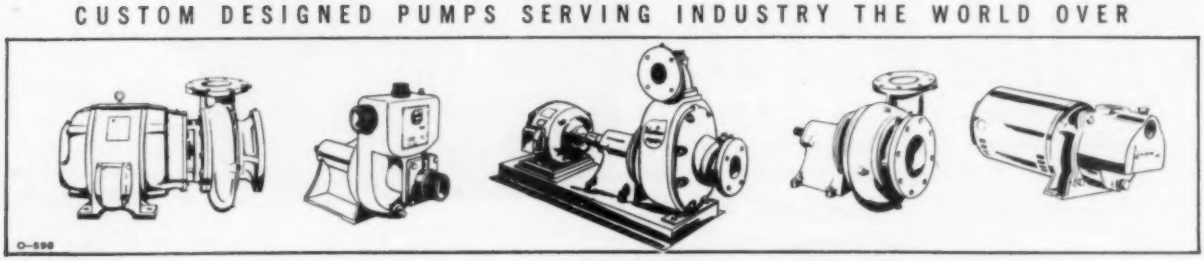
MARLOW PUMPS
Division of Bell & Gossett Company
MIDLAND PARK, NEW JERSEY
Longview, Texas • Morton Grove, Illinois

CUSTOM DESIGNED PUMPS SERVING INDUSTRY THE WORLD OVER



CIRCLE 141 ON READER SERVICE CARD

Globe's basic high quality motors are designed hysteresis-synchronous and induction in various stack lengths. Our a.c. motors span the torque spectrum through 10 oz. in. at synchronous speed (induction torques are 50% higher). New frame sizes of ½" and 2½" dia. are coming. Units are for 60, 400 cycles, variable frequency, very high cycle, or special square wave power. Our d. c. motors span the same performance and size range.

We furnish gearmotors—using standard odd or even ratio gear reducers—providing the exact speed-torque output you need in one compact package. This is the most efficient way to meet your requirements from the standpoints of good design, reasonable cost, undivided responsibility. Many available for immediate prototype delivery.

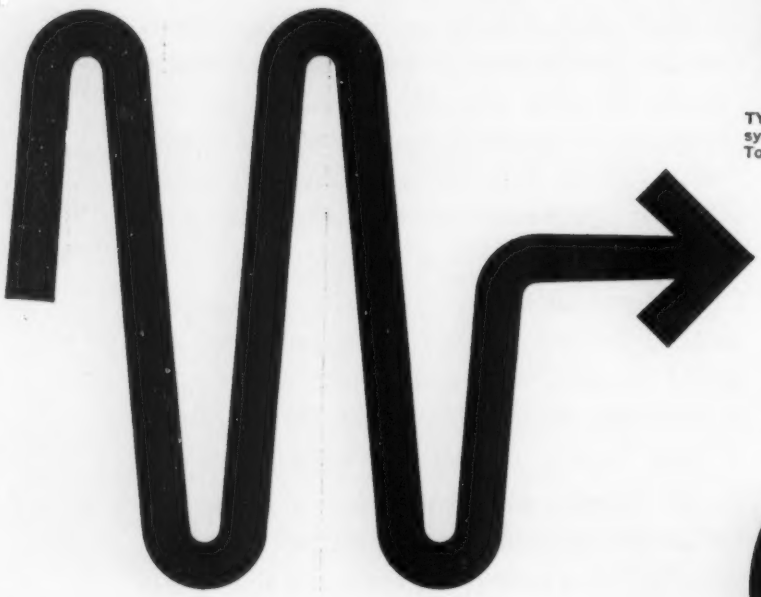
Please ask for Bulletin AC-1 from Globe Industries, Inc., 1784 Stanley Avenue, Dayton 4, Ohio. Tel. Area Code 513 222-3741.

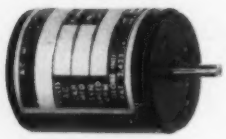
GLOBE INDUSTRIES, INC.

GLOBE

PRECISION MINIATURE MOTORS, GEARMOTORS, TIMERS, ACTUATORS, CLUTCHES, BLOWERS, MOTORIZED DEVICES

OF COURSE, GLOBE MAKES A.C. MOTORS

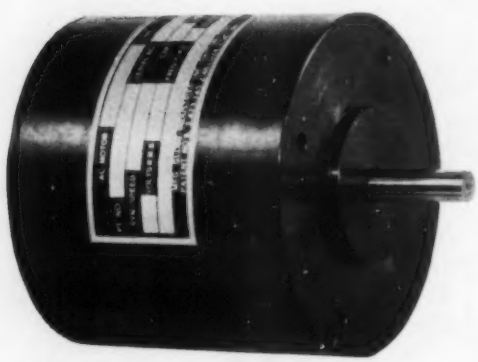




TYPE SC Sub-miniature motor rated .15 oz. in. max. sync. torque. Size: 1.07" dia. x 1.32" long. 2.4 oz. To 200 v. a. c. 2, 4, or 6 poles. 49 std. gear ratios.

TYPE MC Miniature motor rated 0.8 oz. in. max. sync. torque. Size: 1¼" dia. x 2¼" long. 6.5 oz. To 200 v. a. c. 2, 4, or 6 poles. 101 std. gear ratios.

TYPE FC Small motor rated 1.6 oz. in. max. sync. torque. Size: 1 11/16" dia. x 2¾" long. 13.4 oz. To 200 v. a. c. 2, 4, or 6 poles. 101 std. gear ratios.



TYPE LC Small motor rated 10 oz. in. max. sync. torque. Size: 3 5/16" dia. x 3¼" long. 53 oz. To 200 v. a. c. 2, 4, or 6 poles. Gearing to order.

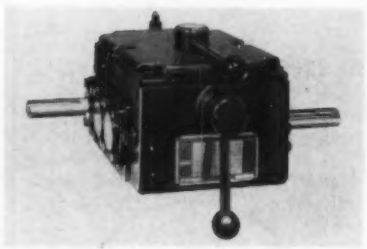
with a common driven valve. Volumetric efficiencies are better than 95% over operating range, permitting gang of pumps to be used for metering in complex liquid fuel systems. Displacement ranges from 0.2 to 1 cu in. Pumps are suitable for service up to 6000 rpm and range from 6 to 7½ in. long and from 3½ to 5½ in. dia. Weights are from 6 to 30 lb. **Clevite Ordnance, Div Clevite Corp, 540 E 105th St, Cleveland 8.**

Circle 311 on Reader Service Card

Air bearing spindles . . .

are reported to be accurate to within one millionth in. Use "annular capillaries" to control fluid flow through bearings, eliminating need for conventional pads and orifices. Have radial deflection rate of 2½ millionths per lb and axial rate of ½ millionth per lb when operated on filtered shop air at 170 psi. Proportionally greater rigidity is possible with pressures up to 2000 psi. Air consumption is approx 2 cfm at 170 psi. Units' 60-lb rotors can be started turning by a torque of 3 gm cm. Can be started, stopped or reversed without disturbing axial position. **Professional Instruments Co, 6824 W Lake St, Minneapolis 26.**

Circle 312 on Reader Service Card



Reversing transmissions . . .

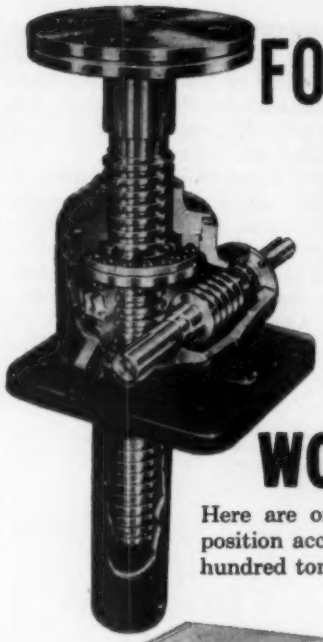
are available in seven sizes from 2 to 75 hp. Include shaft location and mounting arrangements, plus splash-lubricated bearings and gears. Hinged motor mounting plate and mounting base are available for compact installation. **Turner Uni Drive Co, 3416 Terrace St, Kansas City 11, Mo.**

Circle 313 on Reader Service Card

Checking cylinder . . .

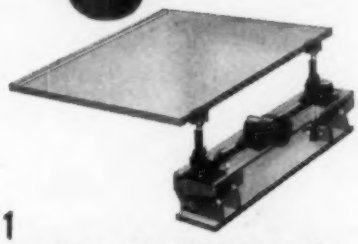
designed to work with any suitable air cylinder, has a max checking capacity of 1000 lb on the "out" stroke with free return. Smooths out stroke speed variations and provides dial-set speed control at any desired stroke

continued, page 144



FOR ACCURATE MOVEMENT OF LOADS...USE DUFF-NORTON WORM GEAR JACKS

Here are only four examples of the many ways to position accurately loads weighing as much as several hundred tons with Duff-Norton Worm Gear Jacks.



1

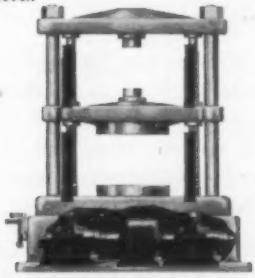
An application with two Duff-Norton Worm Gear Jacks mounted on swivel subbase and each lifting screw end fastened to hinged member by means of clevis and pin. Jacks may be motor driven or manually operated.

2

Four Duff-Norton Worm Gear Jacks connected in rectangular arrangement by Duff-Norton Mitre Gear Boxes, shafting and flexible couplings and driven by gear motor to raise metal sheets to press level.

3

Six Duff-Norton Worm Gear Jacks as used on pipe-cut-off and threading machines to adjust height of machine spindle to level of conveyor table to compensate for various sizes of pipe.



4

Platen pressure obtained positively and uniformly by two Duff-Norton Worm Gear Jacks with rotating screws.

There are eight standard models of these jacks—capacities range from 2 to 100 tons, with standard raises up to 24 inches.

For engineering drawings of standard jacks, mitre gear boxes and more examples of how Duff-Norton Worm Gear Jacks are used for accurate movement of loads, write for Bulletin AD-66a-DD.

DUFF-NORTON JACKS

DUFF-NORTON COMPANY

Four Gateway Center, Pittsburgh 22, Pennsylvania

The Canadian Duff-Norton Co., Ltd., Toronto 6, Ontario

DUFF-NORTON JACKS
Ratchet • Screw
Hydraulic • Worm Gear

COFFING HOISTS
Ratchet Lever • Air
Hand Chain • Electric

CIRCLE 143 ON READER SERVICE CARD

LET MUELLER MAKE IT!

Mueller Brass Co. of Port Huron is much more diversified than the name "Brass" implies . . . a lot more. In fact, because of its many and varied facilities . . . its *men, methods* and *metals* . . . Mueller is in the unique position of being able to offer true single source service.

MUELLER HAS THE MEN . . . experienced engineers with the ability to work out, creatively, tough design problems, and improve a part or components for production by the most economical method. You get sound engineering plus 44 years of practical metalworking production experience when you "Let Mueller Make It."

MUELLER HAS THE METHODS . . . when you "Let Mueller Make It", you are utilizing one single source that is able to produce parts any one of these ways: as forgings, impact extrusions, sintered metal parts, screw machine products, formed tube or as castings.

MUELLER HAS THE METALS . . . and the materials . . . to produce precision parts in aluminum, brass, bronze, copper, iron, and steel in hundreds of different alloys to meet each exact requirement.

In addition, Mueller Brass Co. has complete and modern facilities for performing all types of finishing and sub-assembly operations. Another plus value is nation-wide sales engineering service.

So, in the final analysis, no matter where you fit in the American industrial picture, whether you're making missiles or mowers . . . and no matter where you're located, it will pay you to LET MUELLER MAKE IT!

MUELLER BRASS CO.
PORT HURON 29, MICHIGAN

speed from 3 to 300 in. per min. Construction includes chrome-plated steel piston rod with wrench flats, built-in rod wipers and oil reservoir with visual "low" signal built-in. Available in standard checking stroke lengths through 18 in. (longer stroke lengths on request). Tagged as economy version of 2000-lb capacity unit. **Modernair Corp, 400 Preda St, San Leandro, Calif.**

Circle 314 on Reader Service Card

Silicon-controlled rectifiers . . . include JEDEC types and offer microsec switching speeds and low firing current (5 ma at 212 F). JEDEC types 2N1842 through 2N1849 are rated 10 amp over peak reverse voltage range of 25 to 400 v and operate over temperature range of from −40 to 212 F. Another group is electrically, but not mechanically, equivalent to JEDEC types 2N681 through 2N688. They are rated 16 amp over peak reverse voltage range of 25 to 400 v and operate over temperature range of from −85 to 257 F. Both series can withstand peak one-cycle surge current of up to 150 amp. From stock at $11.25 to $75 each in quantities of 1 through 99. **International Rectifier Corp, 233 Kansas St, El Segundo, Calif.**

Circle 315 on Reader Service Card

4-cylinder diesel engine . . . develops 49 hp at 2200 rpm. Has 3⅞ x 4⅜-in. bore and stroke and 175-cu in. piston displacement. Includes such features as replaceable

continued, page 146

RIGHT... on the spot for spot heating

Vulcan Cartridge Heaters are *right* on the spot . . . for spot heating . . . with a complete quality controlled line which includes standard; high watt density; and ceramic elements.

VULCAN STANDARD CARTRIDGE HEATERS

Vulcan Cartridge Heaters are available in a wide choice of lengths, diameters, sheath materials, wattage and voltage ratings.

VULCAN "THUNDERBOLT"

The "Thunderbolt" delivers as much heat as a conventional cartridge *5 times its size.* You get ratings as high as 200 watts (or even higher) *per square inch* of radiating surface.

VULCAN CERAMIC HEATERS

These are ideal for volume production in spot applications which require a cartridge type unit where high watt density and ruggedness are not prime requisites.

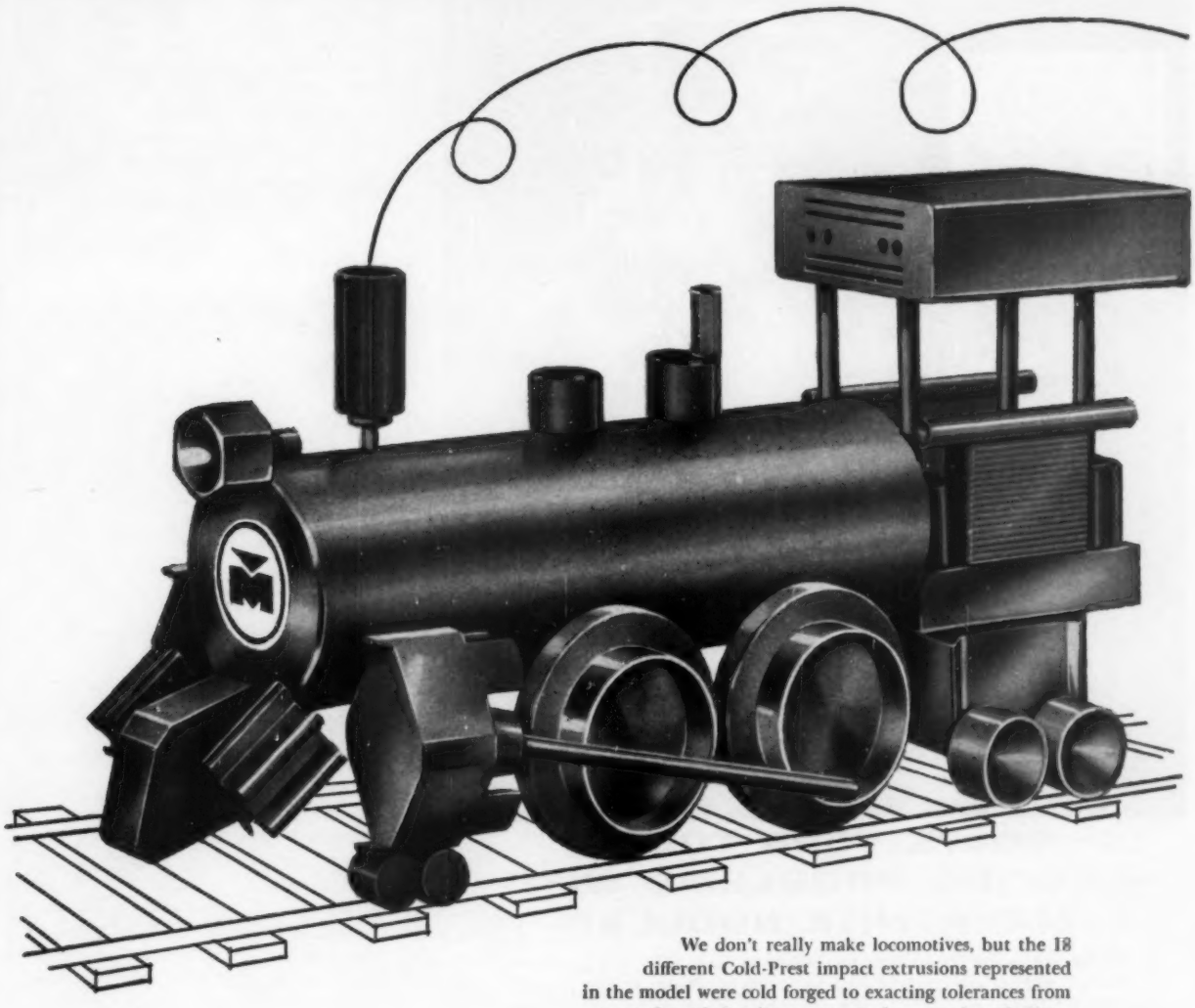
Write for Bulletin *VG*-300A.

VULCAN

Versatility in Electric Heating

VULCAN ELECTRIC COMPANY, Danvers, Mass.

MUELLER CAN MAKE MOST ANYTHING IN IMPACT EXTRUSIONS...



We don't really make locomotives, but the 18 different Cold-Prest impact extrusions represented in the model were cold forged to exacting tolerances from a number of aluminum, copper, brass, and steel alloys.

These parts are employed in products ranging from door closers to missiles. Mueller has also made important advances in the production of copper impact extrusions that are especially adaptable to electronic applications. Cold forgings are precision produced to exacting tolerances and offer the additional advantage of a better finish and appreciable metal savings.

Mueller's flexible facilities for the production of Cold-Prest Impact extrusions make practical long or short runs of simple or relatively complex shapes on an economical basis. In addition, the entire Mueller engineering staff, excellent machining, finishing and assembly facilities are readily available to you when you . . .

LET MUELLER MAKE IT!

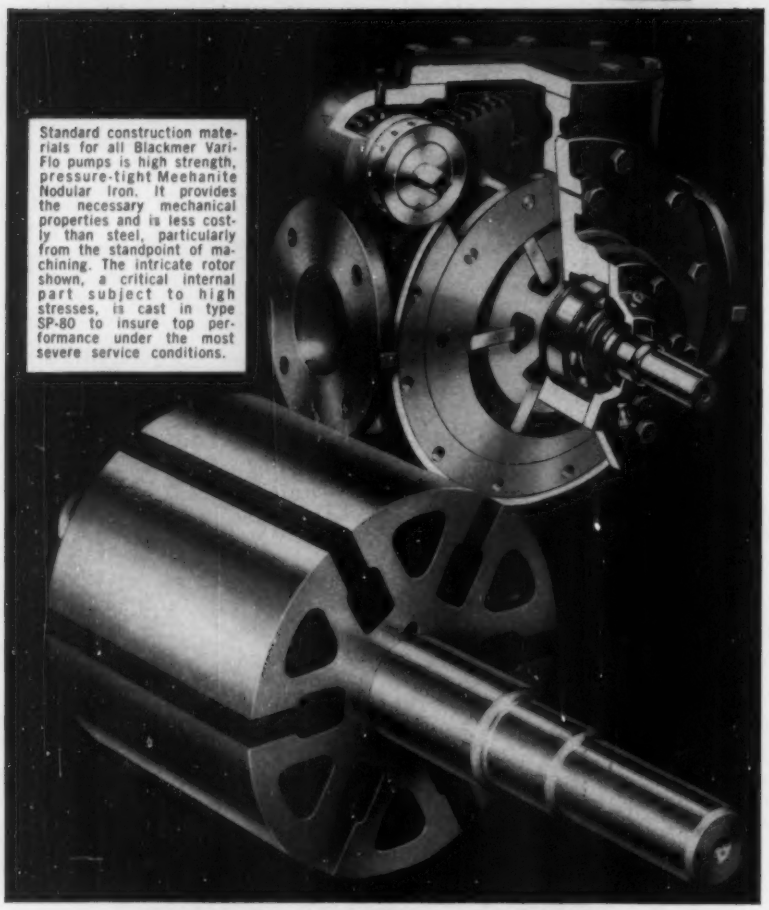
MUELLER BRASS CO.
PORT HURON 29, MICHIGAN

Write today for Engineering Manual No. FM-3019

344

CIRCLE 145 ON READER SERVICE CARD 145

MEEHANITE MEANS BETTER CASTINGS®



Standard construction materials for all Blackmer Vari-Flo pumps is high strength, pressure-tight Meehanite Nodular Iron. It provides the necessary mechanical properties and is less costly than steel, particularly from the standpoint of machining. The intricate rotor shown, a critical internal part subject to high stresses, is cast in type SP-80 to insure top performance under the most severe service conditions.

SOLVE YOUR TOUGH CASTING PROBLEMS WITH MEEHANITE NODULAR

The excellent castability of Meehanite Nodular in combination with exceptional strength, ductility and wear resistance has led to its wide acceptance for intricate pressure castings and many other components which must withstand severe service conditions. The broad range of its utility is further enhanced by inherent production advantages resulting in a reduction of manufacturing costs.

Meehanite Nodular is available in a broad range of properties embracing all current Nodular specifications and including some unique new wear and heat resisting types. When you specify one of the S types of Meehanite Nodular, you can be sure of obtaining castings that live up to specified claims. Meehanite foundries have more than a quarter of a century of experience in handling the essential materials used to convert the graphite in cast iron from the flake form to the nodular which gives this family of metals its unique engineering properties. Meehanite patented quality controls assure uniform dependability regardless of how small or how large the casting.

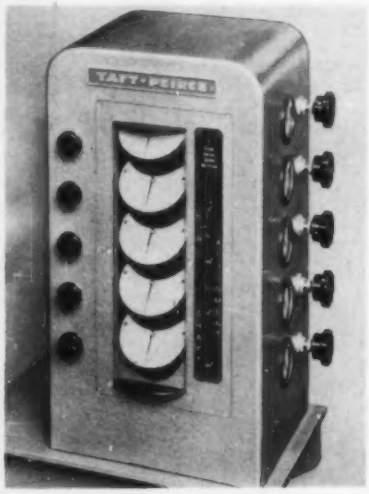
For complete information about Meehanite Nodular, send for a free single copy of our eight page brochure (B-47-A). Write: Meehanite Metal Corporation, 714 North Avenue, New Rochelle, New York.

MEEHANITE METAL

MEEHANITE CASTINGS ARE MADE ONLY BY MEEHANITE FOUNDRIES.

"wet" type cylinder sleeves and full pressure lubrication, which is said to prolong engine life when used with efficient air and oil filtering systems. Engine is adaptable for use by construction industry, on irrigation and other pumping jobs, in logging, sawmill and woodworking operations and by agriculture. Optional equipment engineered for unit can broaden application range. **Allis-Chalmers Mfg Co, Milwaukee, Wis.**

Circle 316 on Reader Service Card



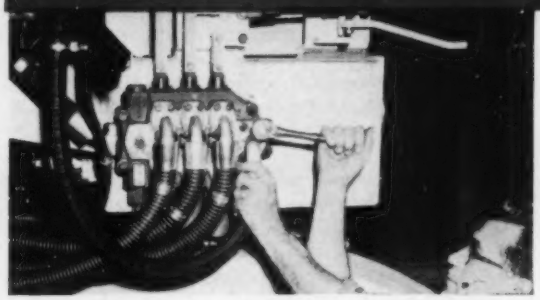
Air gage cabinet . . . measuring only 10¼ x 18½ x 9 in., provides at-a-glance reading of five gage points. Dials are arranged at 45° angle to cabinet panel, in vertical rows as opposed to horizontal rows used with most multi-dial units. Design allows building of multi-unit gages which are smaller than any comparable device whenever five or more indicators are needed. **Taft-Peirce Mfg Co, Woonsocket, RI.**

Circle 317 on Reader Service Card

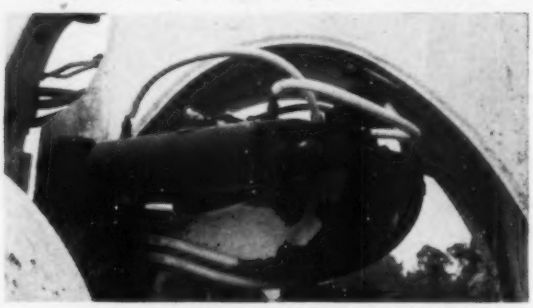
Aircooled gasoline engines . . . originally designed for rotary lawn mowers and other garden equipment, are available in 2.5- and 3.5-hp models. Each comes in two basic versions: stripped model for use "as-is" on competitive priced equipment or with customer-designed shroud and additional accessories for higher-priced equipment (designed to accept existing shrouds used on 4-cycle models); and factory-styled model, which incorporates a pancake type fuel tank for lower silhouette. Easy starting is accomplished by use of a new magneto and 20% greater running time on a

continued, page 148

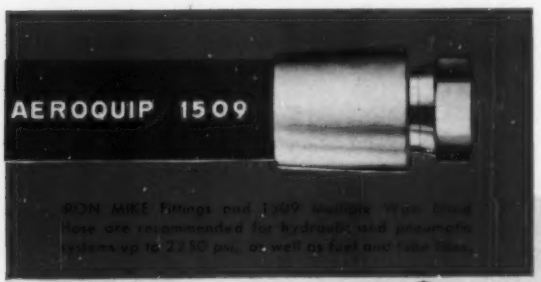
New Aeroquip Fitting Wins Place on Major Equipment



IRON MIKE Fittings are installed on the production line in the plant of a major construction equipment manufacturer.



Checked after lengthy field service, Aeroquip Hose Lines with IRON MIKE Fittings proved they could withstand the most punishing tests.



IRON MIKE Fittings and 1509 Multiple Wire Braid Hose are recommended for hydraulic and pneumatic systems up to 2250 psi, as well as fuel and lube lines.

NEW, LOW-COST REUSABLE FITTING PROVEN DEPENDABLE

Exhaustive field testing proved to one major equipment manufacturer that Aeroquip's new IRON MIKE Fitting meets their requirements best for high pressure hose lines. It combines the rugged dependability and field service advantages of a reusable fitting with the low initial cost of a non-reusable fitting.

This manufacturer is now standardizing on Aeroquip High Pressure Hose and IRON MIKE Fittings for heavy-duty hydraulic lines on all of its equipment.

IRON MIKE Fittings are now available for hose sizes from ¾" to 2" I. D., in ten standard end styles to meet a wide range of equipment applications. For full details, return the coupon below.

PATENT APPLIED FOR

Aeroquip

AEROQUIP CORPORATION • JACKSON, MICHIGAN
INDUSTRIAL DIVISION
INDUSTRIAL PLANTS: VAN WERT, OHIO; BURBANK, CALIFORNIA; DALLAS, TEXAS; PORTLAND, OREGON; CRANBURY, NEW JERSEY
In Canada: Aeroquip (Canada) Ltd., Toronto 19, Ontario
In Germany: Aeroquip G.m.b.H., Baden Baden-Oos
AEROQUIP PRODUCTS ARE PROTECTED BY PATENTS IN U.S.A., CANADA AND ABROAD

Aeroquip Corporation, Jackson, Michigan PE-11
Please send me Bulletin 651 on new IRON MIKE Fittings.

Name_____

Title_____

Company_____

Address_____

City_____ Zone_____ State_____

- Large Manufactured Head
- Oversize Blind Head
- Plugged or Hollow
- No Stem Trimming
- Minimum Blind-Side Clearance
- Excellent Head Seating
- Wide Grip Range
- Full Range of Diameters
- Positive Hole Fill
- Easy Installation

For fast, secure, more economical fastening, the new Cherry Commercial Rivet is a blind fastener ideal for production manufacturing and repair. Installed by one man from one side of the work, the Cherry Commercial Rivet reduces cost of assembly, repair and maintenance in both blind and open applications.

Minimum blind side clearance, adaptability to variations in material thickness, and positive hole fill even in oversize or out-of-round holes offer advantages not available in other production fasteners.

Cherry Commercial Rivets are available in both hollow (non-structural) and plugged (structural) types. The plugged rivets have strength values comparable to solid rivets, and stems fracture to eliminate all trimming operations and provide further production economy.

Grip lengths from 1/8" to 1" inclusive, and diameters of 3/16", 5/32", 1/8" and 1/4" are provided in either universal or countersunk head. Special rivets are manufactured to order.

For full technical information on the new Cherry Commercial Rivet, write Cherry Rivet Division, Townsend Company, Box 2157-D, Santa Ana, California.

Aluminum Mild Steel Monel

CHERRY RIVET DIVISION

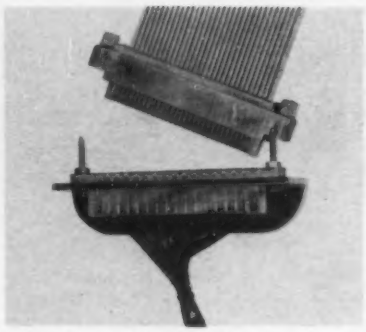
SANTA ANA, CALIFORNIA

Townsend Company

In Canada: Parmenter & Bulloch Manufacturing Company, Limited, Gananoque, Ontario

tank of fuel is said to result from airplane type diaphragm carburetor. Set to maintain optimum operating speed of 3200 rpm, units also are equipped with mechanical flyball governors which prevent them from running wild. All components are close coupled to power head to eliminate harmonic vibrations. Made of die-cast aluminum with bronze bearings on connecting rods and power takeoff end of crankshaft. Magneto end of crankshaft is equipped with heavy duty needle bearings. **Lauson-Power Products Div, Tecumseh Products Co, Grafton, Wis.**

Circle 318 on Reader Service Card



Back and panel connector . . . joins up to 42 round wires to flat conductor cable in a matter of seconds. Terminals are attached to round wires and snapped into the female receptacle. Flat cable with its 42 conductors is folded into connector for direct mating with round wire terminals. Complete connector is polarized for positive mating. Said to be suitable for pull-out drawers, door hinge and quick disconnect applications. **Thomas & Betts Co, 36 Butler St, Elizabeth, NJ.**

Circle 319 on Reader Service Card

Digital set power supplies . . . with both constant voltage and constant current output selected by operator, cover ranges of 100 and 1000 v dc at currents of 100 ma and 1 amp. Reported to have repeatable accuracy of 0.01% and absolute accuracy of 0.05%, as referenced to international volt, as corrected. Long time stability is measured in weeks, not days or hours, because of chopper stabilizing in both reference and power circuits. Operator dials output voltage or current desired without need of calibrating or balancing null meters. Special internal circuit prevents damage if unit remains without load on constant

continued, page 152

When should you use Mercury-Wetted Contact Relays?

IF YOUR RELAYS MUST

SWITCH UP TO 100 TIMES PER SECOND

HAVE A LIFE IN EXCESS OF A BILLION CYCLES

BE COMPLETELY RELIABLE AND FREE FROM CONTACT BOUNCE

THEN SPECIFY P&B MERCURY WETTED CONTACT RELAYS

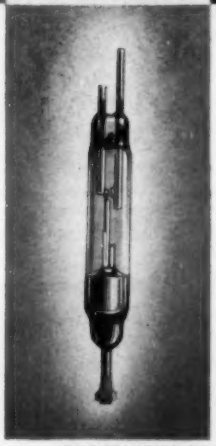
An unusual combination of advantages found only in mercury-wetted relays has led many design engineers to specify them for tough switching jobs. Here are but 3 typical characteristics of our JM series:

RELIABILITY. Sealed-in-glass mercury contacts are renewed with every operation. Won't pit or weld. Make or break is positive . . . every time. No bounce, no chatter. Signals ranging from a few micro amps to 5 amps are switched with singular consistency.

LONG LIFE. Think in terms of *billions* of operations when considering JM series relays. Proper application, of course, is a requisite.

SPEED. Operate time is just less than 3 milliseconds using 2 watts of power. Release time is about 3.2 milliseconds. Thus, relays can be driven 100 times per second.

If your project calls for exceptional relay performance, perhaps the answer lies in our JM Mercury-Wetted contact relay.



JM SERIES ENGINEERING DATA

Contact Rating:
5 amperes maximum
500 volt maximum
250 volt-amp max. with required contact protection.

Contact Configuration:
Each capsule SPDT. Combination of capsules in one enclosure can form DPDT, 3PDT, 4PDT. (All Form D.)

Terminals:
Plug-in or hook solder; 8, 11, 14, or 20-pin headers.

Coil Resistance:
2 to 58,000 ohms.

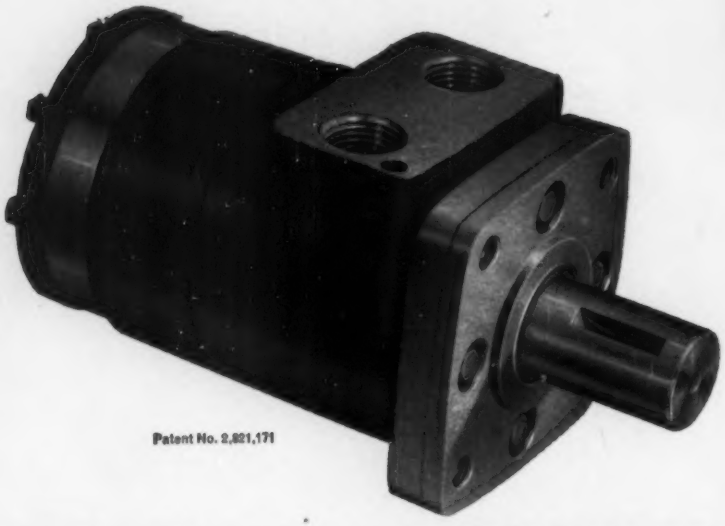
More information?
Write today for free catalogue.

P&B STANDARD RELAYS ARE AVAILABLE AT YOUR LOCAL ELECTRONIC PARTS DISTRIBUTOR

POTTER & BRUMFIELD

DIVISION OF AMERICAN MACHINE & FOUNDRY COMPANY • PRINCETON, INDIANA
IN CANADA: POTTER & BRUMFIELD, DIVISION OF AMF CANADA LIMITED, GUELPH, ONTARIO

HIGH TORQUE at SLOW SPEED

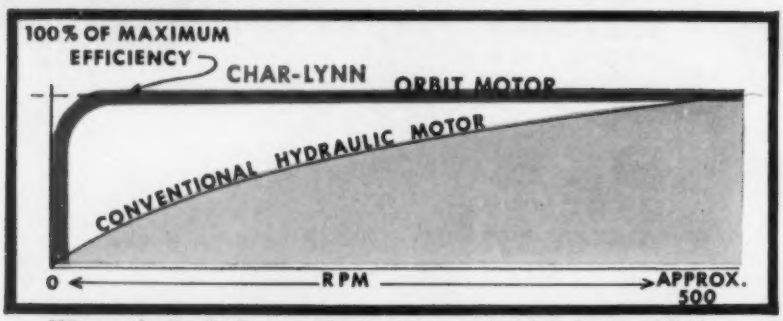


Patent No. 2,821,171

New Char-Lynn Hydraulic ORBIT MOTORS® deliver Full Torque regardless of speed range

It's Here—A NEW concept in fluid power mechanics has brought about the development of a totally new fluid motor—A *High Torque—Low Speed* motor.

These motors open up complete new areas for design, never before possible. They offer a practical and economical hydraulic solution to the age-old problem of providing High Torque at Low Speeds for constant and variable speed drives—hydrostatic transmissions and remote controls *without* bulky, costly mechanical drives and gear reducers.

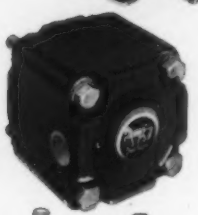


Whereas hydraulic losses make some conventional designs prohibitive at the lower speeds, Char-Lynn ORBIT MOTORS maintain high efficiency over the complete operational range.

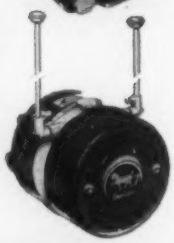
- Speeds from 0—800 RPM
- Torques to 3300 inch lbs.
- Starting torque substantially equal to running torque
- Fully reversible — instantaneous starting—stopping
- Only 3 moving parts
- 4 types of mountings available
- 3 port sizes—7 power element selections
- Compact—lightweight
- Eliminates costly and complicated power transmissions
- High volumetric and overall efficiency

complete your HYDRAULIC CIRCUITS with Char-Lynn COMPONENTS

HOLDKONTROL VALVE V-960

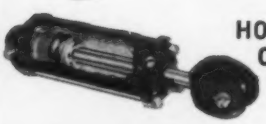


HORSEPOWER PUMP 400



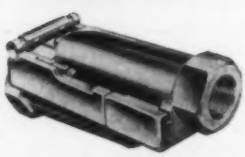
HI-LO POWER PAC PUMP P-600

STROKONTROL CYLINDER C-133



HORSEPOWER CYLINDER C-102

HYDRAULIC FLUID FILTER F-240



HOSE COUPLER H-730

For complete details write **Dept. HM Char-Lynn Company** • 2843-26th Avenue South, Minneapolis, Minnesota

Char-Lynn HYDRAULIC HORSEPOWER PRODUCTS

Some Ideas

for your file of practical information on drafting and reproduction from

KEUFFEL & ESSER CO.

Frankly, we hope you're a fusspot. If you are fussy about the way you work, and proud of it, we think you'll enjoy knowing about these K&E items . . .

A Real "Clinging Vine"

Some of our more meticulous K&E people have been known to walk out of a drafting room in a cold sweat at the way the drafting boards were covered. Its those ripples, wrinkles and bends that cause all the anxiety. "How," mutters our loyal agent, "can you expect to draw a straight line on a wavy surface?"

And its all so easy if you just take the right K&E product and mount it in the right way. The product in this case is LAMINENE® N70 Board Surface Material. This is a product *unique* with K&E. We hold a patent on the process that *laminates* a thin acetate film to a tough paper base – quite a bit different than simply *coating* a paper with plastic. And the results are different too.

It's rather a dramatic show of force that LAMINENE stages on a board. The secret is in the irresistible urge of a natural product to return to its normal state. In this case, when you *wet* the back of LAMINENE you expand it ever so slightly. When tacked or taped under the edges of the board, it begins to dry and shrink. The paper backing builds tension on the surface as it dries, finally reaching a smooth taut state . . . with enough tension left over to keep it permanently wrinkle-free. No matter what the temperature or humidity, LAMINENE stays with the board as if cemented there.

Add to this a fine, springy quality, and a variety of other features – grid lines, green color, washability – and you can see why LAMINENE rates at the top in popularity for a semi-permanent board covering.

Would you like a sample? It's yours for the asking. See your K&E dealer or return the coupon at the right.

Time Saving Stickers

Want to eliminate a time-consuming chore? You can cut down on tedious repetitive lettering by having title blocks, specifications, and other symbols or legends printed – clearly and sharply – on DULSEAL™ (74). This tissue-thin film has a delayed-action adhesive on the back, and a dull finish face for easy writing or printing.

Stickers made of DULSEAL can be firmly positioned–and re-positioned hours later, just as firmly. The adhesive takes 24 hours to set. Once it does set, a permanent bond is formed with the paper or cloth beneath. DULSEAL is chemically stable, and the adhesive will not bleed, even in hot copying machines.

Repeated erasures on DULSEAL will not affect its "take." Produced by an exclusive process, the "tooth" is *built into* the surface. Transparent and low in reflectivity, DULSEAL stickers will not affect the transparency or printing speed of your drafting medium. K&E supplies DULSEAL in sheets, rolls (printed to your specifications if you wish), and as a mending tape in a handy dispenser. Try a sample, on us!

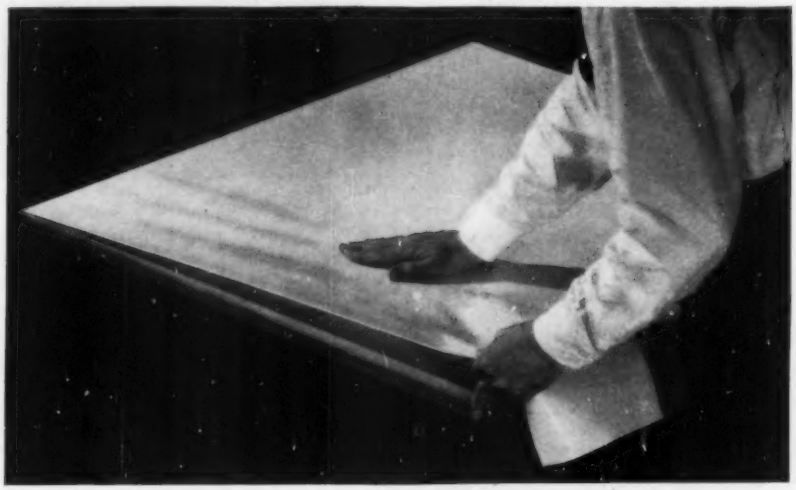
3 To Keep Clean

Best way to keep your tracings clean: don't let them get dirty. A mighty easy way to achieve this is to sprinkle the tracing lightly with gum eraser particles, while working. Then, triangles, T-squares, and scales stay clean, and clean the surface *automatically*, as they are moved back and forth. The particles will not dry out or harden – they contain no grit or abrasives. They'll actually improve the ink taking qualities of your drafting surface.

For this purpose, K&E supplies cleaning particles put up in three different ways. We think the new plastic squeeze-bottle (3036C) is the handiest of all. The shaker-top can (3036) has also been a drafting-room favorite for some time. And, for double-duty cleaning, we suggest the ABC DRY-CLEAN PAD™ (3037) or DRY-CLEAN JR.™ (3037J)–a smaller version–which hold slightly coarser granules that sift through soft mesh. The ABC Pad also comes in handy for wiping a complete tracing after it is finished, or for preparing certain surfaces for ink work. Or for an overall pre-cleaning, since the best way to insure clean tracings is never to let soil build up.

The proverbial ounce of prevention is worth the traditional pound of cure!

These K&E products, and others that can make life easier for you, are available from your nearby K&E dealer. See him soon . . . or send us the coupon below for further information and samples.



KEUFFEL & ESSER CO., Dept. PD-11 Hoboken, N. J.

Please send me samples and information on LAMINENE® Drawing Board Surface Material, and DULSEAL™ Tape . . . plus information on K&E cleaning powders.

Name & Title_____

Company & Address_____

_____

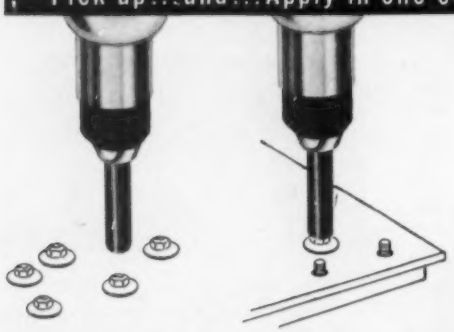
4259-B

In addition to low price and vibration-proof fastening—

PALNUT® LOCK NUTS and FASTENERS Slash Assembly Time and Costs!

High-speed, automatic assembly provided by PALNUT FASTENERS and PALNUT WRENCHES

Pick up...and...Apply in one continuous operation

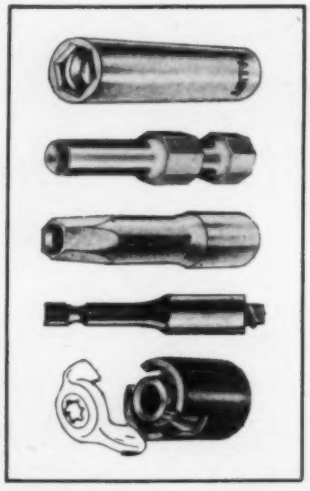


Magnetized PALNUT wrench picks up PALNUT Fastener from supply tray. PALNUT is held firmly by magnet for easy, fast starting and tightening.

PALNUT Lock Nuts and Fasteners assemble easily and fast with any standard power or manual tools . . . but assembly is further simplified and speeded up by using specially-designed PALNUT magnetized wrenches. No fumbling with hand starting. Spin on freely. Precise quality control assures uniformly high tightening torque, accurate fit and reduced rejects.

OTHER ASSEMBLY SAVINGS

PALNUT Lock Nuts and Fasteners can eliminate extra parts such as lock washers, flat washers, sealer washers, cotter pins—eliminate extra operations such as threading, annular grooving, drilling of parts. Assemblers handle only a single, low-cost PALNUT Fastener.



THE PALNUT COMPANY
DIVISION OF UNITED-CARR FASTENER CORPORATION
65 Glen Road, Mountainside, N. J.
Canada: P. L. Robertson Mfg. Co., Ltd., Milton, Ont.

WRITE for detailed catalogs on PALNUT Lock Nuts, Fasteners and Tools. Describe application for recommendation and free samples.

PALNUT® LOCK NUTS

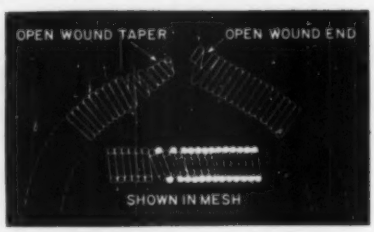
Reduce Costs • Reduce Parts • Speed Assembly • Hold Securely • Save Space • Save Weight

current circuits. No potentiometers are used in setting output. All steps are in nature of definite switch positions and allow setting to 1 part in 10,000 (0.01%) of output range selected. Ripple is below 0.002%. **Davenport Mfg Div., Duncan Electric Co Inc, Dept PE-1, 2530 N Elston Ave, Chicago 47.**

Circle 320 on Reader Service Card

Right-angle gearmotors . . . have single reduction worm gearing for use with apparatus driven by belts, chains or spur gearing, as well as through couplings. Available in both ac and dc integral type, units are offered with ac motors in NEMA frame sizes 182 (1 hp) to 286U (20 hp) or with dc motors in sizes 187A (1 hp) to 286A (15 hp). Single reduction worm gearing is said to offer high-ratio reduction with few moving parts in a close-coupled drive. Right angle drive arrangement requires min space. Involute helicoid thread form used with worm gearing gives it high load capacity and efficiency. **Westinghouse Electric Corp, PO Box 2099, Pittsburgh 30.**

Circle 321 on Reader Service Card

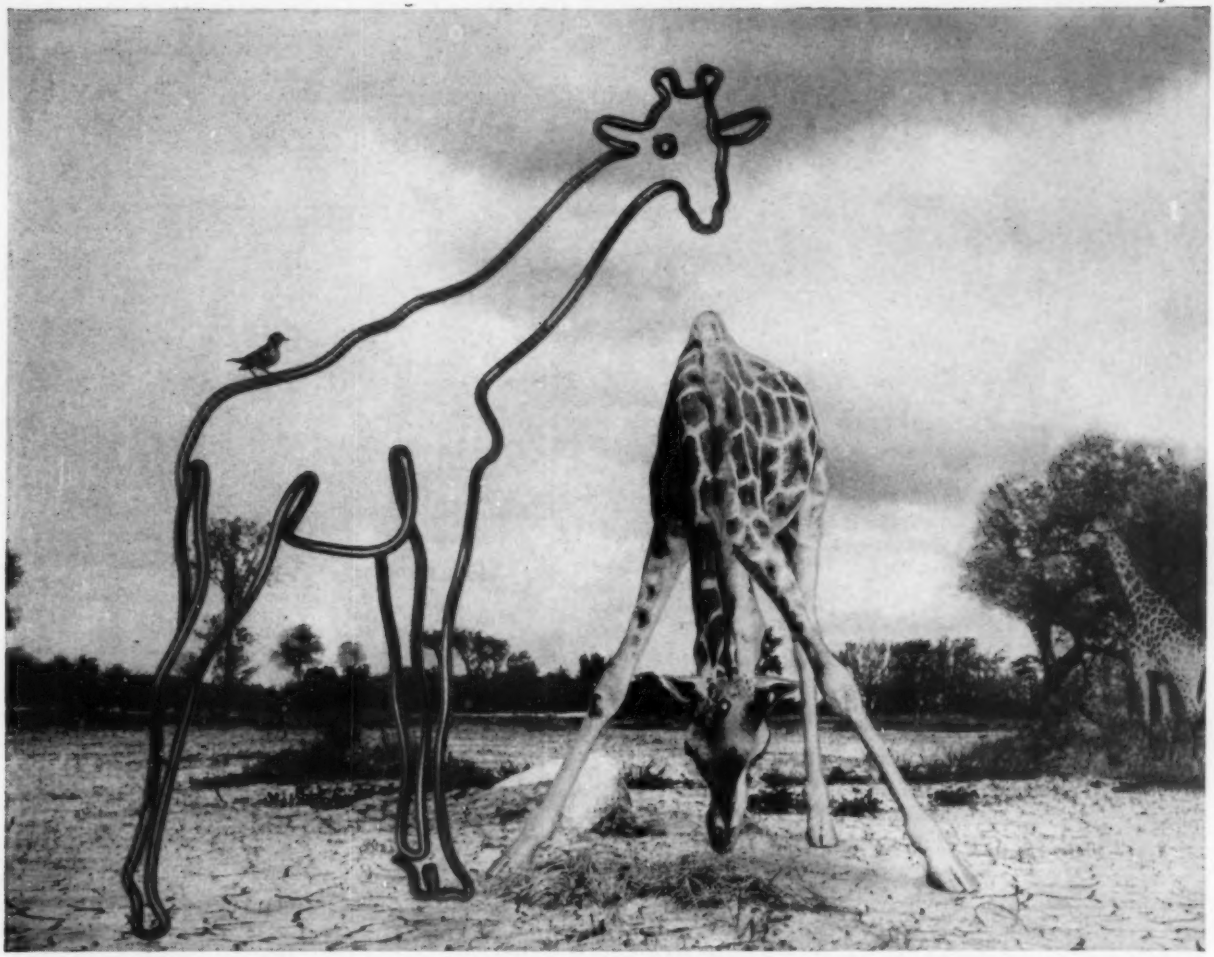


Garter springs . . . have positive end connections which reportedly provide smooth continuity of OD across joint. Instead of reducing male end of coil for insertion into coils of other end, connection involves interlacing of coils to prevent distortion of the connection. This method is said to improve flexibility at the joint and provide spring with high resistance to lateral stress. Available in wide range of commercial sizes in compression and extension types. **Associated Spring Corp, Bristol, Conn.**

Circle 322 on Reader Service Card

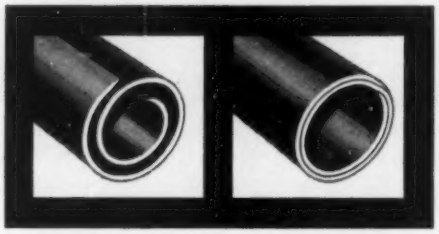
Miniature vibrator . . . weighing 7½ oz, handles up to 10-cu ft capacity bins. Used to bring powdered, particulate or crystalline materials out of hoppers, down chutes and through screens. Works silently

continued, page 157



Bundy can mass-fabricate practically anything

No matter what tubing components you may need, chances are Bundy can mass-fabricate them better. Bundy engineers design their own mass-fabrication machinery—can often point out modifications that mean important cost savings for you. And there are few things you can't make with Bundyweld® steel tubing. It meets Government Specifications MIL-T-3520, Type III; ASTM 254; and SAE specifications. Use Bundy's tubing experience on your tubing problems. For the complete Bundyweld story, call, write, or wire us at any time: Bundy Tubing Company, Detroit 14, Mich.



* * *

Bundyweld, double-walled from a single copper-plated steel strip, is metallurgically bonded through 360° of wall contact. It is lightweight, uniformly smooth and easily fabricated . . . has remarkably high bursting and fatigue strengths. Sizes up to ⅝" O.D.

BUNDY® TUBING COMPANY

DETROIT 14, MICH. • WINCHESTER, KY. • HOMETOWN, PA.

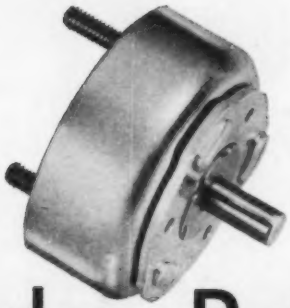
WORLD'S LARGEST PRODUCER OF SMALL-DIAMETER TUBING. AFFILIATED PLANTS IN AUSTRALIA, BRAZIL, ENGLAND, FRANCE, GERMANY, ITALY, JAPAN

CIRCLE 153 ON READER SERVICE CARD 153

Now, make your urea moldings come alive with an unmatched surface brilliance—without sacrificing quality or economy. Three new high gloss formulations make this possible: Beetle 650, designed for small parts such as closures and buttons; Beetle 625, for closures, switch plates, wiring devices and small housings; Beetle 600, for large housings and other parts requiring extended flow. These new Beetle molding compounds cure faster, and they offer improved preforming qualities. And you still have all of these dependable Beetle properties: resistance to detergents, oils and grease; arc-resistance; track resistance; good dielectric strength; surface hardness; stain-resistance; wear-resistance; unlimited range of colors. Be among the first to take advantage of this bright new development. Write for complete information today. *BEETLE — registered trademark for Cyanamid's urea-formaldehyde molding compound.

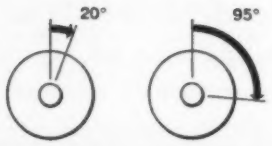
AMERICAN CYANAMID COMPANY CYANAMID PLASTICS AND RESINS DIVISION

WALLINGFORD, CONNECTICUT. *OFFICES IN:* BOSTON • CHARLOTTE • CHICAGO • CINCINNATI • CLEVELAND • DALLAS • DETROIT • LOS ANGELES MINNEAPOLIS • NEW YORK • OAKLAND • PHILADELPHIA • ST. LOUIS • SEATTLE • *IN CANADA:* CYANAMID OF CANADA LIMITED, MONTREAL • TORONTO



Ledex Rotary Solenoid

BASIC INFORMATION



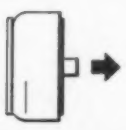
Standard Ledex rotary solenoids will provide rotary strokes from 20° to 95°.

Action is snap-type, with spring return to starting position after completing stroke.

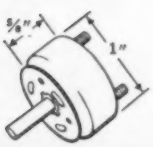
Action is instantaneous, speed: 1/30 sec. for 32° stroke and return.

Available in left hand stroke as well as right.

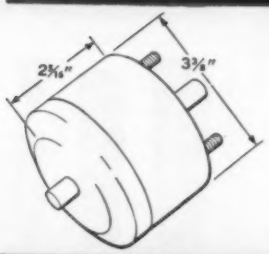
Standard rotary solenoids provide torque always in same direction, stroke. Higher starting torque models can be designed.



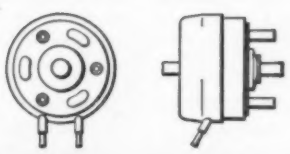
Kit size provide powerful, highly efficient, short stroke piston action.



Smallest is size 7/8, have weight 3/4 oz., torque up to 4 pound inches.



Largest is size 10, have weight 4 lbs. 3 oz., torque up to 98 pound inches.



Standard power take-offs include aluminum plate with three tapped holes and shaft extension from either or both ends. Special designs available.

The Ledex Method of actuation and control gives instantaneous high-torque-to-size rotary motion and high-thrust-to-size piston motion, for reliable remote mechanical actuation or remote control of rotary-type switches.

The efficient Ledex Rotary Solenoid is the heart of this method. Available in 8 compact sizes, with operating voltage from 3 to 300 V.D.C. Over 240 stock models ready for immediate shipment. Used in thousands of applications including valves, tape recorders, waveguide switches, sorting equipment, gyrocaging, computers, wireless teletypes, vending machines, typesetters, missile guidance and ground support equipment.

Other Ledex Method products are Syncramental Stepping Motors, Rotary Stepping and Selecting Switches. Write for Bulletin A-1259, mentioning application, to Ledex Inc., Dayton 2, Ohio; Marsland Engineering, Ltd., Kitchener, Ont.; NSF Ltd., 31 Alfred Place, London, Eng.

LEDEX®

High-torque-to-size rotary motion
High-thrust-to-size piston motion

CIRCLE 155 ON READER SERVICE CARD 155

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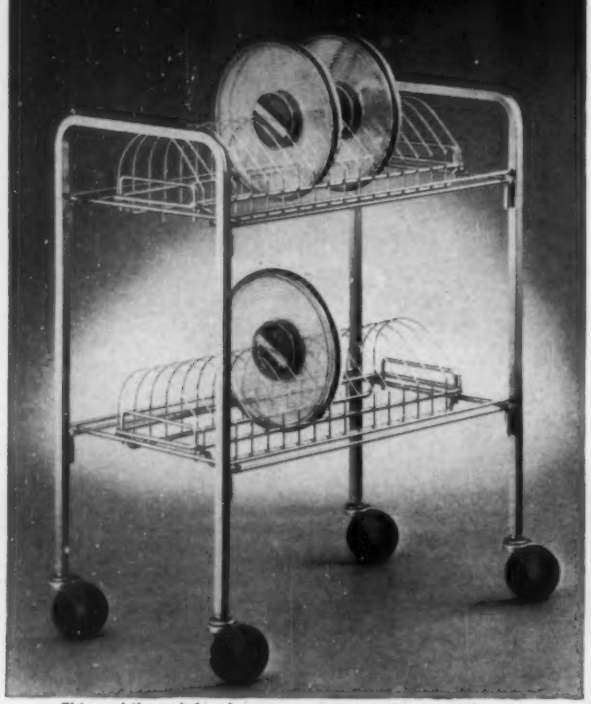

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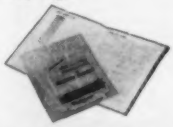

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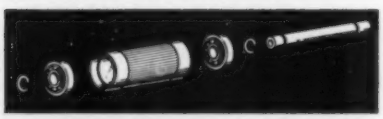

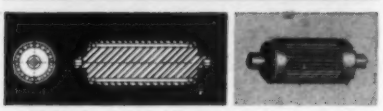

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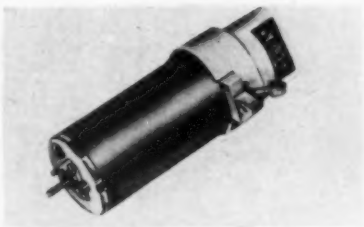

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continued, page 158

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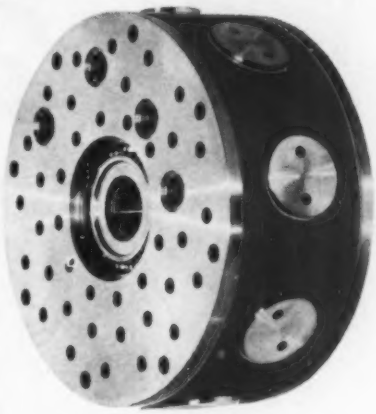

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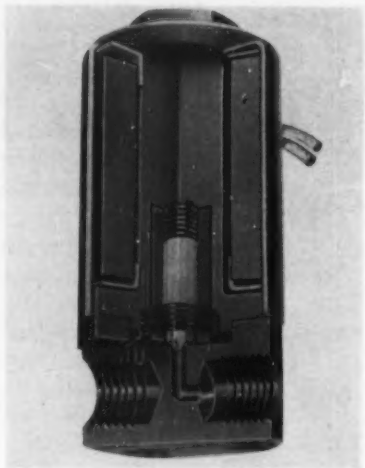

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Key-operated selector switches . . . are NEMA 1 and oiltight control devices available in two, three or four positions for either base or panel

continued, page 174

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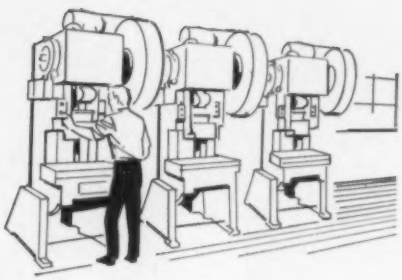

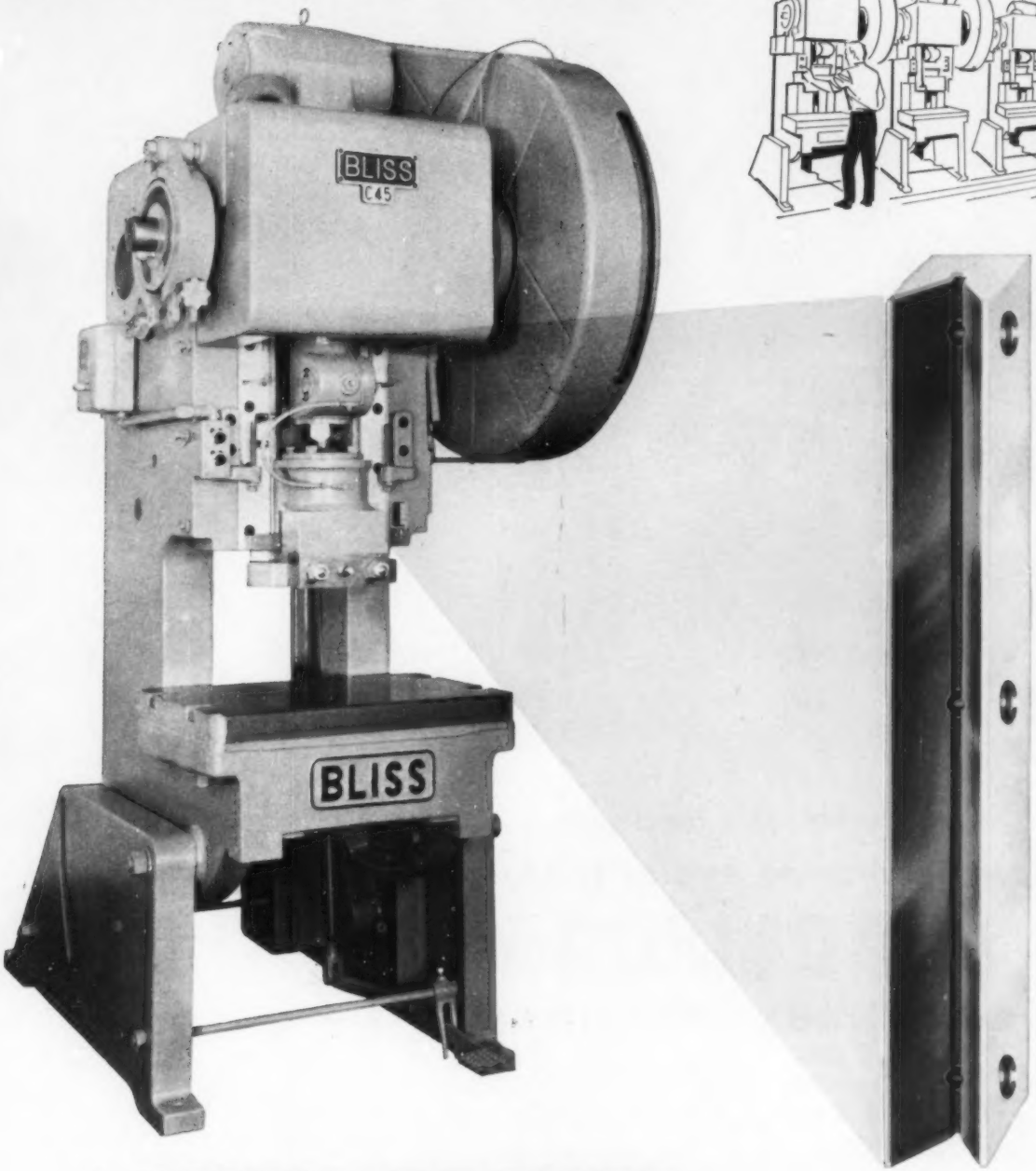

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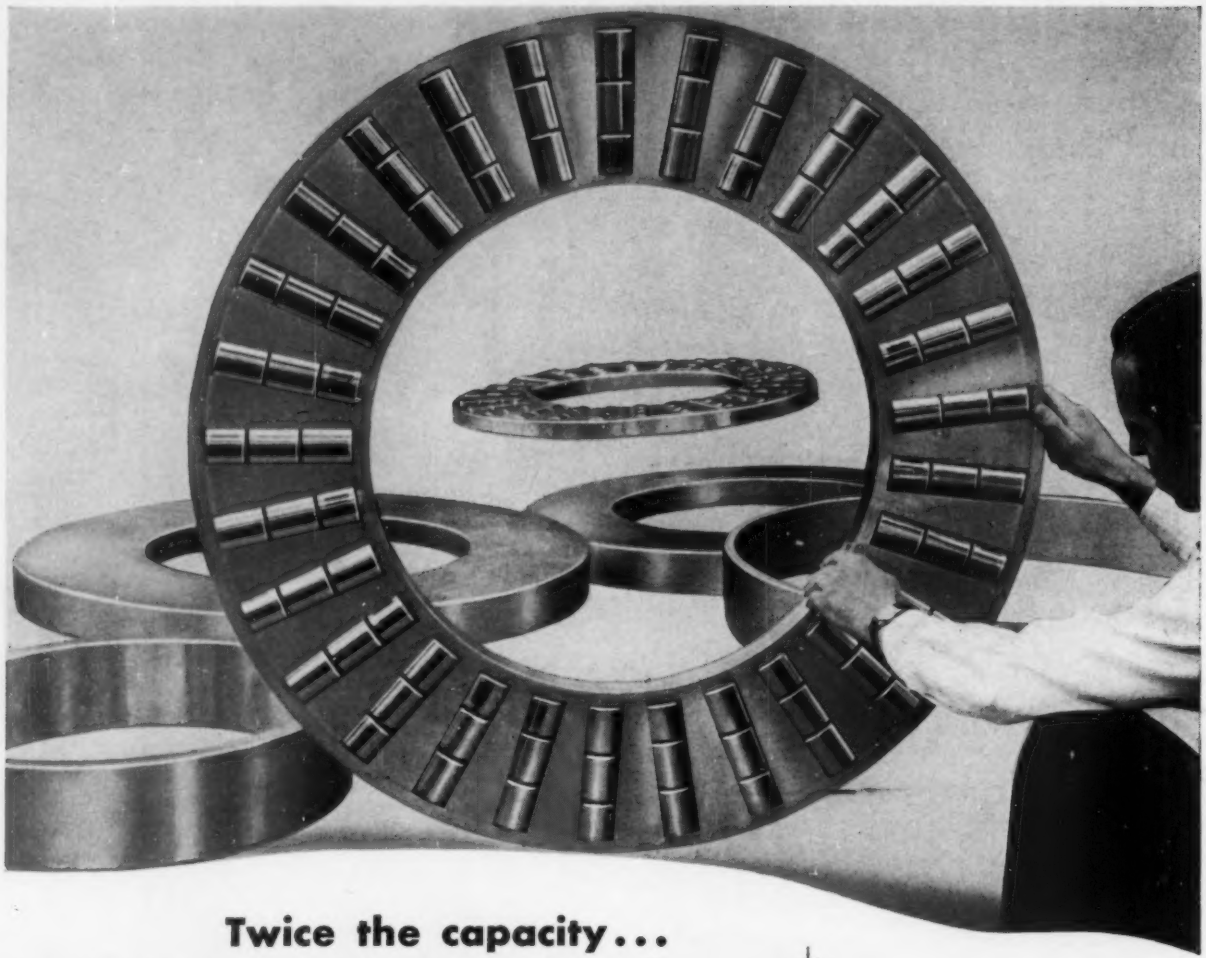

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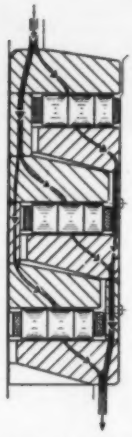

Arrows indicate path of thrust load in tandem-type bearing.

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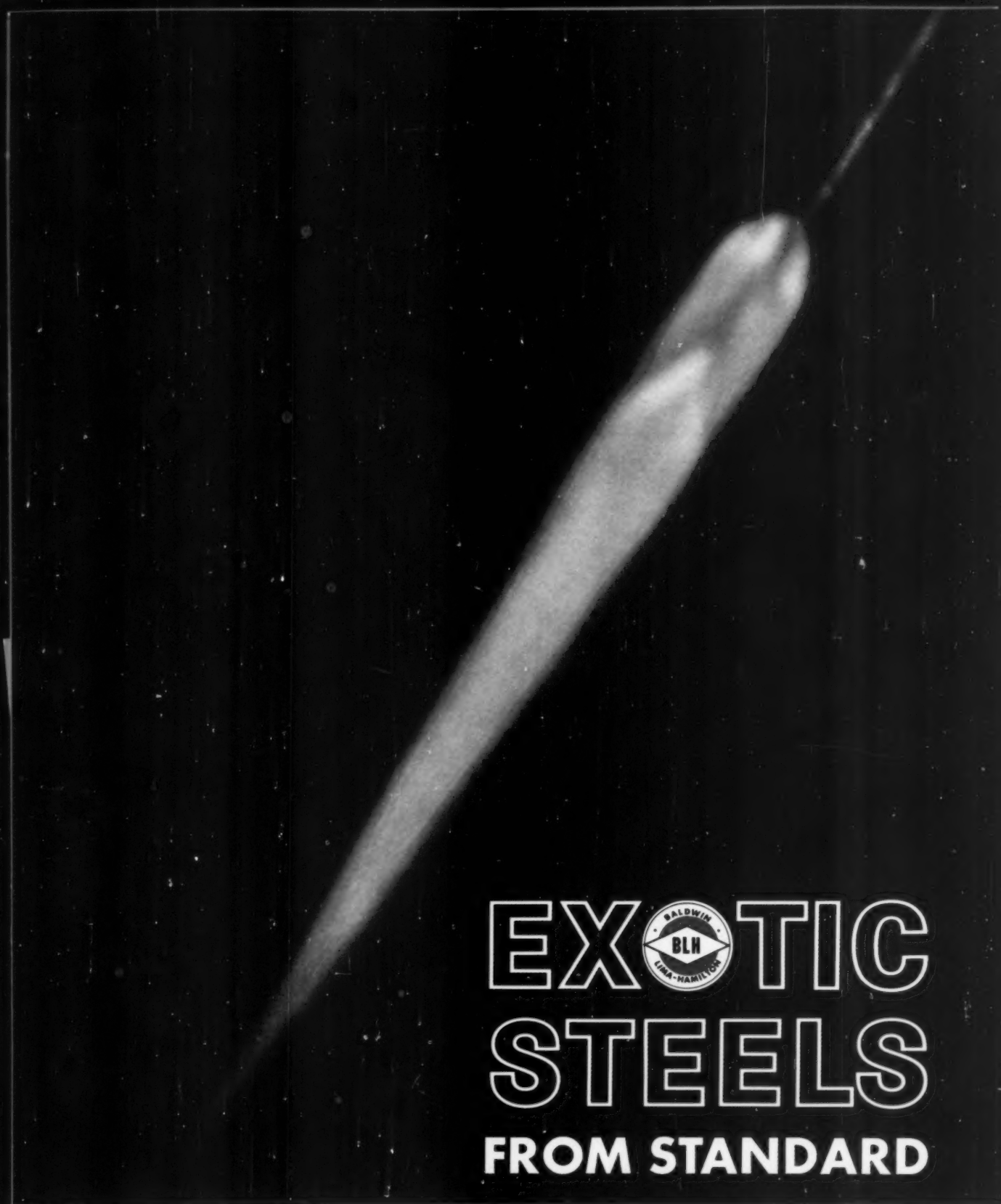
CIRCLE 161 ON READER SERVICE CARD→



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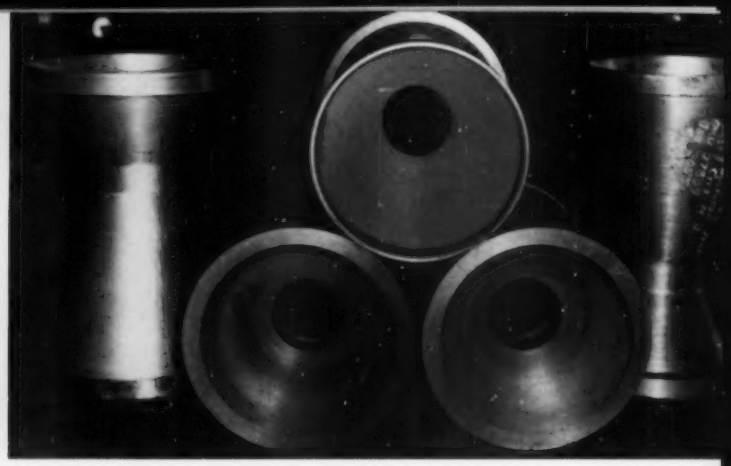

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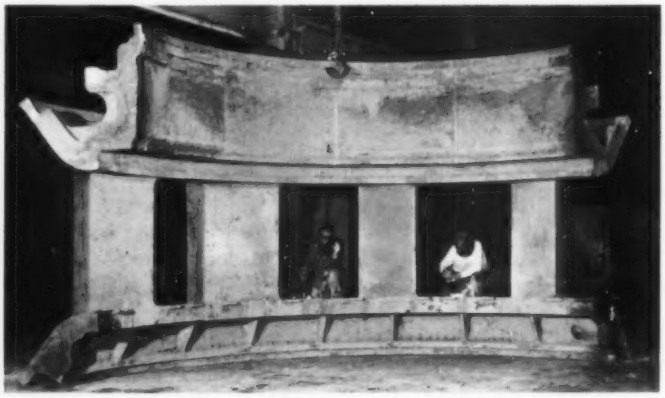

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Your turn

...to participate in the current problems of our profession.

Cryogenic means "very low temperature." Refractory is "heat resistant." High vacuum means "nearly free of gases." Hypersonic means "faster than sound." But what are the dividing lines that set these points off? How do you distinguish between related terms? Your turn first; then check your answers on page 166.

1. What is the *upper* limit of **cryogenic?**
2. What is the *lower* limit of **refractory,** as applied to metals?
3. Where is the dividing line between **high vacuum** and **ultrahigh vacuum?**
4. How do you distinguish between **supersonic** and **hypersonic?** What does **transsonic** mean?
5. What is **ultrasonic,** and in what fields is the term used?

• • • •

The trick in solving **differential equations** is chiefly one of identification: When you've learned to recognize those that practically solve themselves (even though they may look difficult) and to separate them from those that can only be solved by brute force, half the battle is over. In the previous four lessons in this series, Robert P Benedict, development engineer in Westinghouse, has pointed to five general types of equations that have elementary solutions. **Now we are ready for some special equations.** In this lesson he probes two specials: the Euler-Cauchy and the Bernoulli. Next issue—and our last lesson in this series—he will take up two special first-order equations.

The Euler-Cauchy equation, like the equations discussed in the previous lessons, is **a linear, nth order nonhomogeneous equation.** But in this case, the variable coefficients are arranged like this.

$$a_n x^n \frac{d^n y}{dx^n} + a_1 x^{n-1} \frac{d^{n-1} y}{dx^{n-1}} + \cdots + a_{n-1} x \frac{dy}{dx} + a_n y = F(x)$$

Notice that the power of the independent variable equals the order of the differential in each term. It can be solved with the same methods used for the general equation, of course, but there is an easier way.

The Euler-Cauchy equation can always be transformed to an equation with constant coefficients by changing the independent variable to an unknown function of the independent variable. To do this, substitute e^z for each x, where z is a function of x. The terms of the original equation are then expressed in terms of this new function and its derivatives. For example,

$$a_{n-1} x \frac{dy}{dx} = a_{n-1} e^z \frac{dy}{e^z dz} = a_{n-1} \frac{dy}{dz}$$

$$a_{n-2} x^2 \frac{d^2 y}{dx^2} = a_{n-2} \left(\frac{d^2 y}{dz^2} - \frac{dy}{dz} \right)$$

and so on, while $F(x)$ becomes $F(e^z)$. Now substituting these terms gives an equation with constant coefficients, and the solution can be carried out by methods discussed in a previous lesson.

Example: The equation $x^2 y'' + 4xy' + 2y = 0$

is a Euler-Cauchy equation. This can be expressed in terms of constant coefficients by substituting e^z for x to give

$$\left(\frac{d^2 y}{dz^2} - \frac{dy}{dz} \right) + 4 \frac{dy}{dz} + 2y = 0$$

YOUR TURN *continued*

or $$\frac{d^2y}{dx^2} + 3\frac{dy}{dx} + 2y = 0$$

This is a linear, second-order, homogeneous, differential equation with constant coefficients. It can be solved, as before, by replacing the differentials by m's (substituting $y = e^{mx}$) and finding the m's algebraically.

$$(m^2 + 3m + 2)e^{mx} = 0$$

The roots are $m_1 = -1$, $m_2 = -2$, and the general solution is

$$y = c_1 e^{-x} + c_2 e^{-2x}$$

or

$$y = c_1 x^{-1} + c_2 x^{-2}$$

The Bernoulli equation is a special kind of nonlinear, first-order, nonhomogeneous, first degree differential equation. Its general form is

$$y' + F_1(x)y = F_2(x)y^n$$

Except for the y^n, which makes the equation nonlinear, it could be solved by the method outlined for nonhomogeneous, first-order equations. But it can be reduced to a linear differential equation by expressing a new dependent variable in terms of an unknown function of the independent variable namely, $z = y^{1-n}$. This new function and its derivative are substituted into the original equation to obtain

$$z' + (1 - n)F_1(x)z = (1 - n)F_2(x)$$

which is linear and therefore can be solved as before.

Example: The equation

$$yy' + \frac{y^2}{2} = \sin x$$

is a Bernoulli equation if put in the form

$$y' + \frac{y}{2} = \frac{\sin x}{y}$$

With $z = y^2$, the equation can be rewritten as

$$z' + z = 2\sin x$$

Now, turning to the general solution for a linear, first-order, nonhomogeneous equation write the solution

$$z = e^{-x}[2\int e^x \sin x\, dx + c]$$

and substituting back gives the solution for the original equation as

$$y^2 = \sin x - \cos x + ce^{-x}$$

Now you try

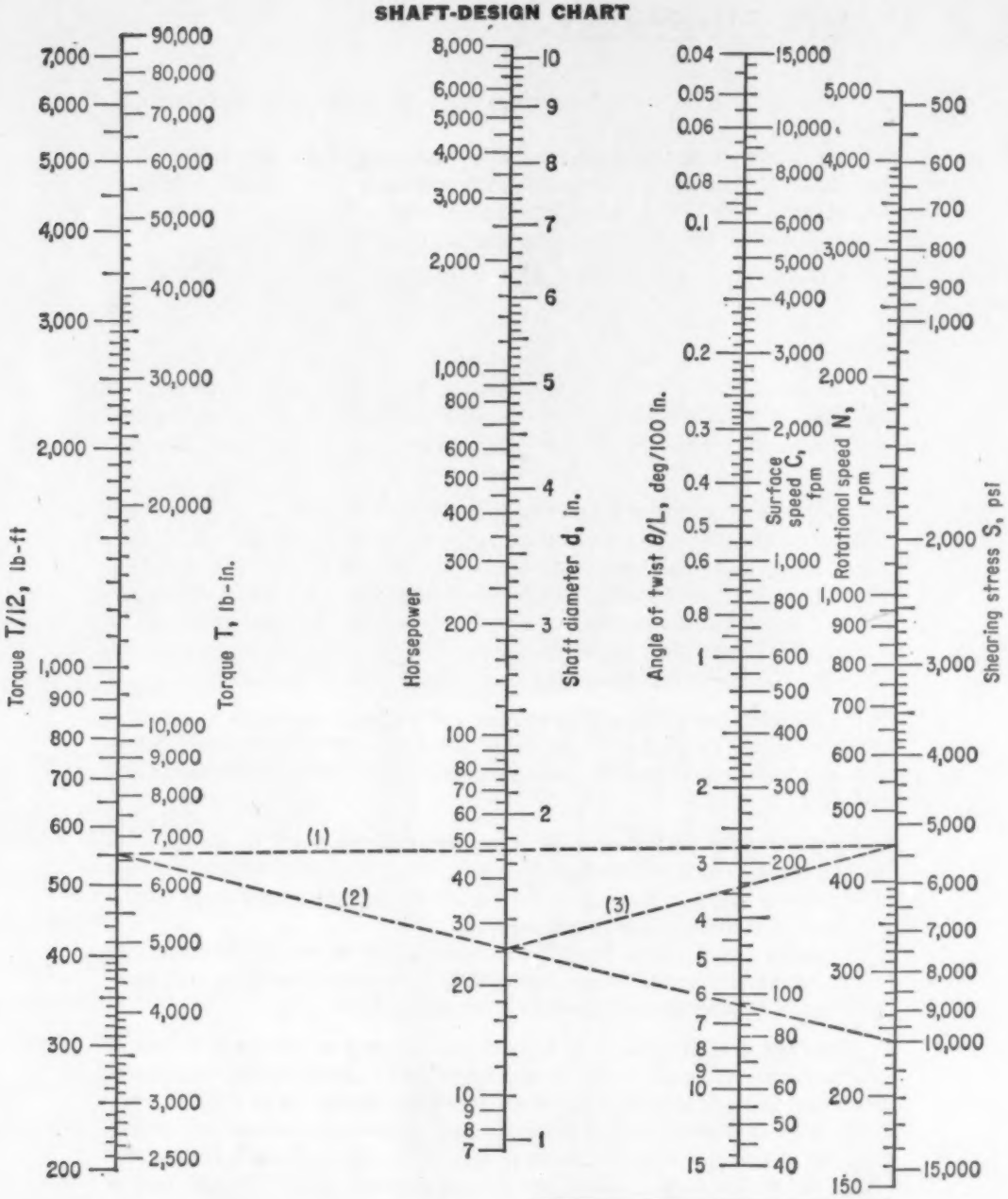
Here three differential equations that fall into the special categories above (two Bernoulli and one Euler-Cauchy). The answers are on page 217.

1. $y' + \frac{1}{x}y = \left(\frac{\ln x}{x}\right)y^2$
2. $x^2y'' + xy' - y = x\ln x$
3. $xy^2(xy' + y) = a^2$

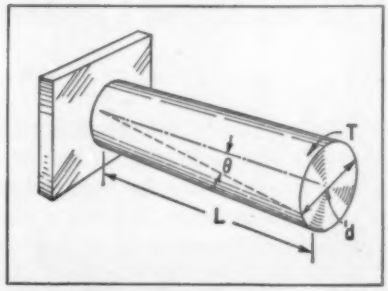
• • • •

It usually isn't worth making nomographs for simple equations unless a long string of repeated calculations is going to be done. But when several short, interrelated equations have to be solved, why not put them all on the same nomograph so that you can proceed from one solution to the next by drawing just one more line? This is what F. Caplan, senior engineer with Kaiser Engineers, Oakland, Calif, has done with four equations for circular shafts. They are →

SHAFT-DESIGN CHART



1 (a). $T = 63{,}000\ hp/N$ in lb-in.
1 (b). $T/12 = 5255\ hp/N$ in lb-ft
2. $S = 5.09\ T/d^3$
3. $\theta/L = 4.865 \times 10^{-3}\ T/d^4$
4. $C = \pi/12\ dN$



SYMBOLS

C = Surface speed, fpm
d = Shaft diameter, in.
E_s = Shearing modulus of elasticity, psi
hp = Horsepower transmitted by shaft
L = Length, in. $\times 10^2$
N = Rotational speed, rpm
S = Shearing stress, psi
T = Torque, lb-in.
θ = Angle of twist, deg
θ/L = Angle of twist per 100 in.

YOUR TURN *continued*

Angular twist is for steel shafts where $E_s = 12 \times 10^6$. For other materials, twist is inversely proportional to E_s.

Here is an example showing one possible path through the nomograph. What size shaft will transmit 48 hp at 450 rpm with max $S = 10{,}000$? Solution: Line 1 gives $T = 6{,}700$. Line 2 finds $d = 1.50$, and also $\theta/L = 6.4$. Line 3 gives $C = 177$. Drawing three lines here has given four answers.

• • • •

Answers to questions on page 163.

1. The upper limit of **cryogenic,** according to National Bureau of Standards is 100 K (–279 F). But Linde takes –150 F as the dividing line, and others have used points as high as –100 F. Any of these figures would constitute a "correct" answer. But the NBS figure is likely to be considered the best choice.

2. Traditionally, a **refractory metal** has been any one with a melting point above 2000 C (3632 F). But a good many tables of refractory metals list rhodium (mp: 3571 F), vanadium (mp: 3452 F) and chromium (mp: 2822 F). Recently, NBS has adopted 1600 C (2912 F) as the dividing line. This would include the first two metals, but not the third. Either 2000 C or 1600 C would be considered a "correct" answer; and, on a practical basis, tables of refractory metals will certainly continue to list chromium even though it's below the line.

3. The dividing line between **high vacuum** and **ultrahigh vacuum** is a somewhat mobile one, too. Generally, though, "high vacuum" is 10^{-6} mm Hg; while "ultra-high vacuum" is 10^{-10} mm Hg and below. Values of 10^{-5} and 10^{-9} would still be "correct".

4. In aerodynamic terms **supersonic** is any speed above mach 1—the speed of sound (741 mph in air at standard pressure). Most commonly, though, the term is restricted to speeds in the mach 1 and mach 5 range; while speeds above mach 5 (in excess of 3700 mph) are called **hypersonic.**

Transsonic simply means "in the same speed range as sound"—a range with special aerodynamic implications, but of little importance elsewhere. (In aero-dynamics, it is generally considered as mach 0.8 to mach 1.2).

5. **Ultrasonic** is an acoustic term that relates frequency of vibrations to that of audible sound. It should never be applied to speed. By definition, it refers to any sound (vibration) with a frequency above the audible range (20,000 cps). It has been applied to units of the siren type, designed for process use (agglo-meration of particles, homogenization of emulsions), some of which operate well within the audible range. This is not, however, correct usage. For this type of device, the term "sonic" is considerably more accurate, and is now being applied.

• • • •

Here's a simple idea that looks like it might work. With a little ingenuity, it shouldn't take much effort to find out.

The idea is to make flat head screws so that they countersink themselves. Robert Marie of Hagerstown, Ind, whose idea it is, suggests that the cone-shaped side of the flatheads be provided with several sloped cutting edges like a countersink. This would eliminate the countersinking operation when drilling holes in plastic, wood or other soft materials. Or perhaps merely running the screw thread up the underside of the head would be sufficient. Maybe a combination of the two designs would work best. In any case, the head should be designed so that it does not leave burrs on the surface or cause excessive compression of the material around the head.

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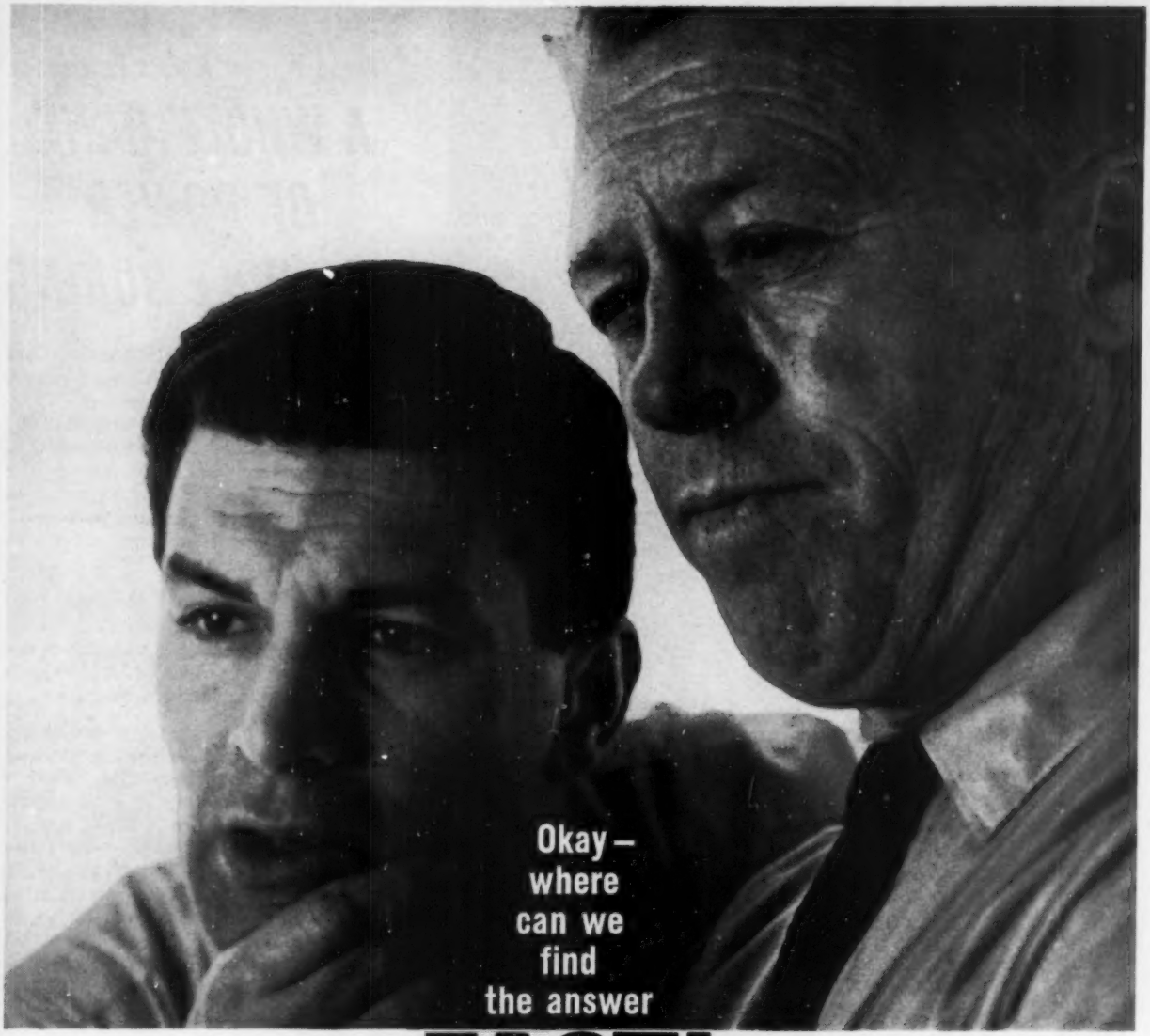

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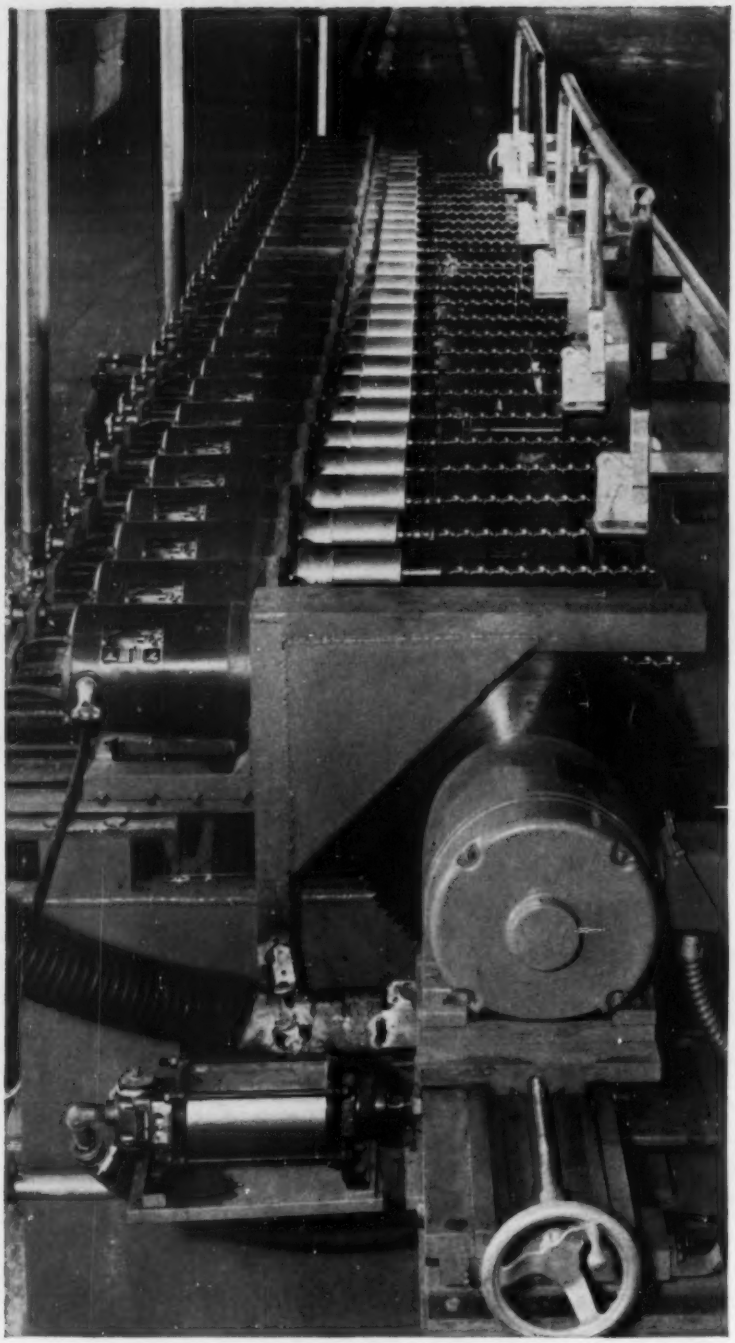

These Wagner Motors Provide...

A WHOLE BANK OF POWER FOR HOLE BORING

Those are Wagner polyphase motors lined up behind the bits. Thirty of them, each rated at one horsepower. They provide the muscle needed to drill thirty holes through six 2 x 4's, simultaneously and in six seconds flat. The saw on the end of the rig—powered by a five horsepower Wagner "Doubly Protected" polyphase motor—cuts the boards to size at the same time.

This wood boring machine, manufactured by the Indiana Foundry Machine and Supply Company, is installed in the new Kopper's Company, Inc. Plastics Division plant in Detroit, Michigan.

It's not too often that you see thirty motors lined up like this, providing power for one machine. But, whether the number of motors in a particular application adds up to 3, 30, or 300 . . . if they're Wagner Motors, you know they're really doing a job. That's usual, for Wagner Motors have been getting the job done for more than 65 years. And, a program of constant research and development in electric motor design makes sure that Wagner Motors will continue to lead *where it counts* . . . in performance!

Mind a suggestion? Call your nearby Wagner Sales Engineer for an analysis of your next motor application, be it for plant or product. Whatever your requirements, Wagner can supply a standard motor, or build a special motor to fit your needs. There are Wagner branches in 32 principal cities across the country, at your service.

Wagner builds Polyphase Motors in ratings from 1/6 through 1,000 hp.; single phase, 15 hp. and smaller.

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SMALL IN SIZE AND COST

You get reliability for the lowest price when you specify the new General Controls K-27 Kompact Solenoid Valve for your equipment. Small as 2⅜" x 1⅝". Light as 7 oz. Fits ⅛" or ¼" pipe. 100% tested for bubble tight shut-off. Pressure ratings available to 1200 psi. Controls air, water, steam, fuel oil, hydraulics or gas. Carefully manufactured and thoroughly inspected. Fill out the coupon. Clip it to your letterhead and mail to Sumner Ladd, Sales Manager, General Controls, 801 Allen Ave., Glendale 1, Calif. We'll send you a sample valve you can try on your own equipment without obligation.

*(Offer limited to original equipment manufacturers. Expires January 31, 1962)

Automatic Controls For Product or Process

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Glendale, California : Skokie, Illinois : Guelph, Ontario, Canada :
Nine Plants: 44 Branch Offices serving the United States, Canada, and Western Europe

Please send me a free sample of your new K-27 Kompact Solenoid Valve to try on our:

_____ (Type of equipment) _____ (Fluid) _____ (Pressure) _____ Pipe Size ☐ 2 way ☐ 3 way

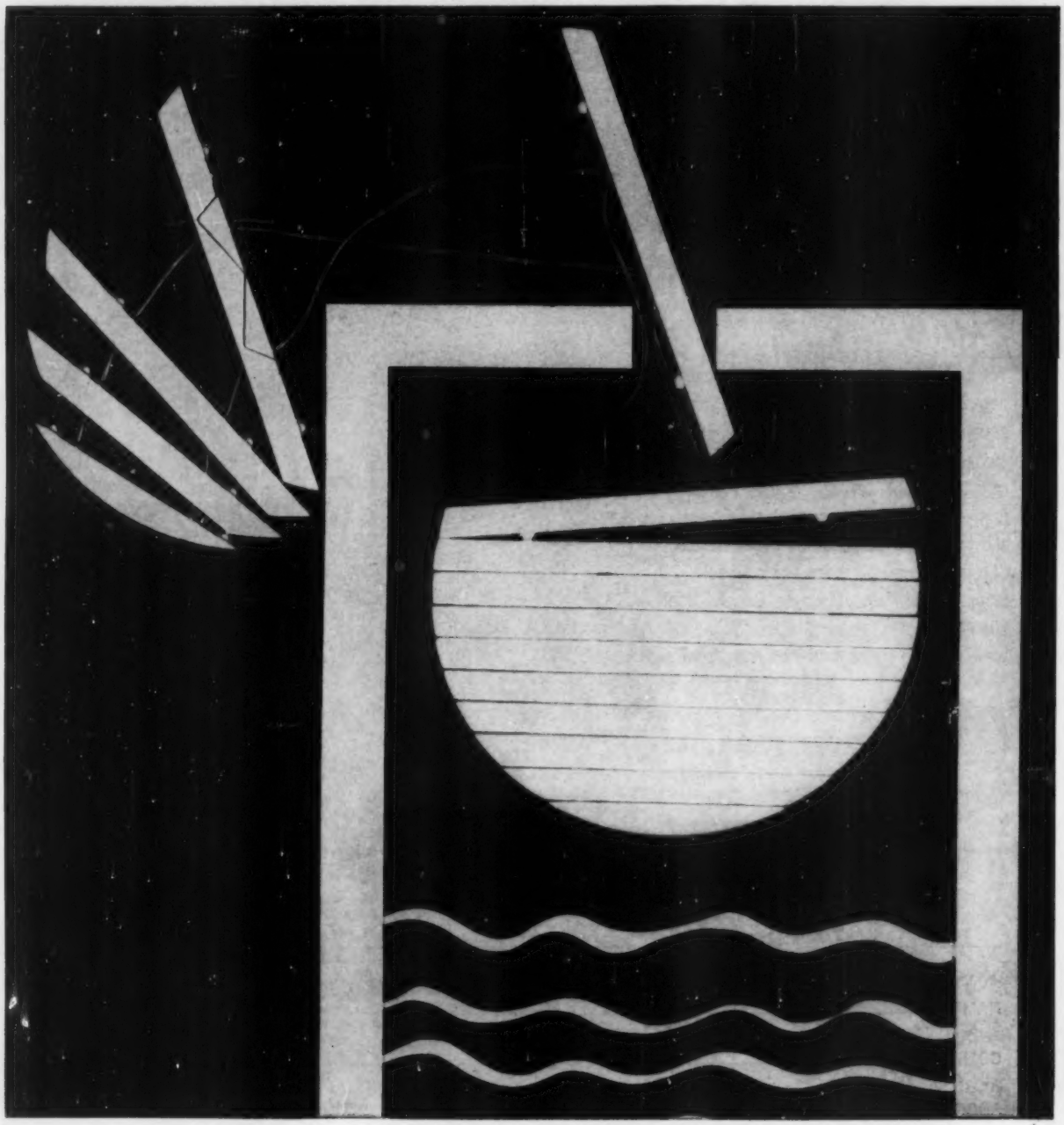
NAME _____ POSITION _____

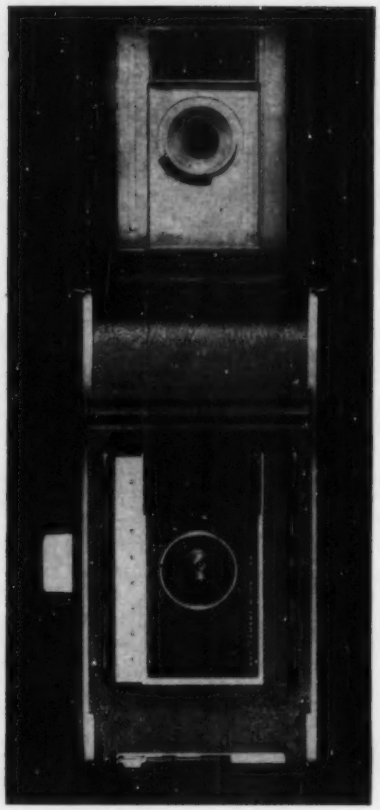
COMPANY _____

ADDRESS _____

Foam plastic ends waterlogging of pressure tanks

The most common problem with home water systems has been in maintaining the right amount of air in pressure tanks. Mechanical air controls haven't done the job because water quickly corrodes their metal parts. Now, Baker Manufacturing Company of Evansville, Wisconsin, has developed the Monitor AirSaver Float molded from lightweight DYLITE® expandable polystyrene. The moisture-proof float covers the surface of the water, and ends air absorption which causes troublesome waterlogging. Even though it's half submerged in water and must constantly withstand pressures of 20 to 40 lbs. psi, the float is guaranteed for 5 years. Designed to install in minutes, the float has a series of DYLITE bars which are highly resistant to rotting, leaking, corrosion and chemical action. They are inserted, one at a time, through a hole in the top of the pressure tank. Tensioning springs lock the bars together, and make the float airtight.





Polaroid uses plastic to hold "electric eye"

When Polaroid designed their new J-66 Land Camera, they needed a strong, heat-resistant material for the front section which secures the electric eye. After investigating many plastics, they chose an easy-to-mold Koppers polystyrene—DYLENE® Type 80. The durable plastic section fits perfectly around the electric eye to keep it firm. DYLENE is easily moldable, speeds production, eliminates costly secondary operations, and doesn't warp when exposed to extreme heat. Investigate versatile DYLENE polystyrene and see how you can lower costs and improve product performance and appearance.

Cooler liner formed without thin spots

The interior liner of this Hamilton-Skotch picnic chest is thermo-formed from SUPER DYLAN® high-density polyethylene. This impact-resistant plastic is used because it's the only polyethylene that can be formed into this difficult deep-draw piece without producing thin spots or mold marks. The seamless liner won't leak, absorb food odors or water. Its smooth, white finish can't stain, discolor, rust or corrode—it's easy to keep clean. Bottles, cans and chunks of ice won't mar or crack its tough surface. Cooler Chest manufactured by The Hamilton-Skotch Corporation, New York 16, New York.

Plastic cartridges pass freeze, pressure tests

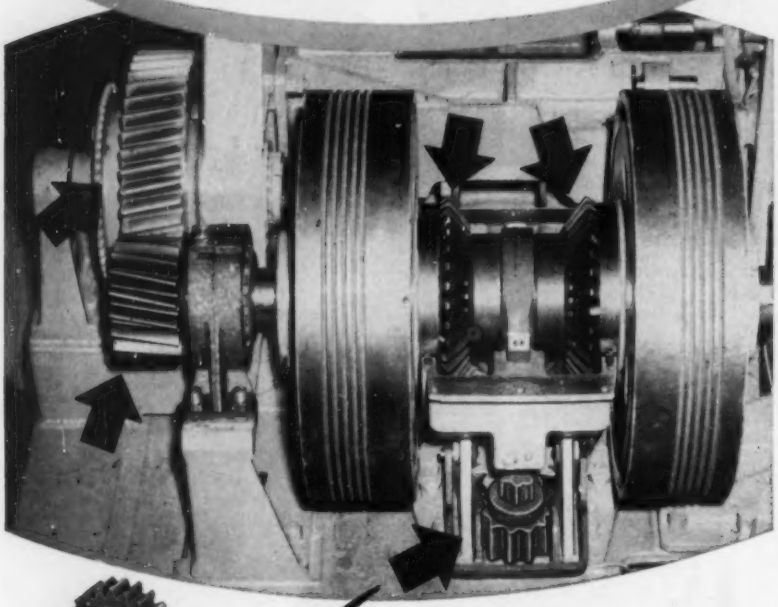
Pyles Industries, Inc., of Detroit, manufactures air-operated caulking guns for the automotive and aircraft industries. To extend storage life of caulking compound, Pyles makes freezable cartridges. Before they selected a cartridge material they tested a number of polyethylenes. Filled test cartridges were quick-frozen at temperatures as low as −80°F. Next, they had to withstand air pressures of 80 to 200 lbs. psi without blowing out or stripping threads on the plastic nozzle. Other polyethylenes became brittle and cracked, but tough DYLAN® polyethylene didn't weaken after repeated freeze and pressure tests.

KOPPERS PLASTICS

No matter what your design problem, investigate our complete line of polyethylenes and polystyrenes. Contact Koppers Company, Inc., Plastics Division, Dept. 1416, Pittsburgh 19, Pa.

KOPPERS

Do You have requirements for "Special Gears?"



✓ CHECK with FAIRFIELD!

"Fairfield has furnished us with bevel and spur gears for many years and we are highly satisfied with their product," states one of America's best known makers of shovels, cranes, and draglines in referring to the above picture. Each gear (*see arrows*) is precison produced to match this builder's specifications for *plus value* quality.

Making gears to meet exacting specifications is our business. The special or unusual requirements you have for design, size, finish, tolerances, materials, and heat treatment are often "standard" at FAIRFIELD. Here, every facility needed is available for production of fine gears EFFICIENTLY, ECONOMICALLY. *LARGE or SMALL, your inquiry will receive prompt attention.* CALL or WRITE.

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TRACTORS • HEAVY DUTY TRUCKS • AGRICULTURAL MACHINERY • POWER SHOVELS AND CRANES
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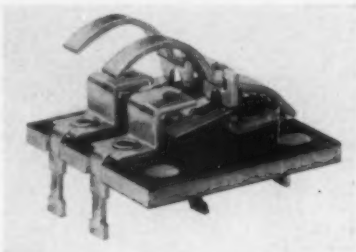
mounting. Ferrules are offered in black, red, green, yellow, white, orange, blue and aluminum color for group coding. Contact arrangements vary from 1 normally open or 1 normally closed to 4 normally open and 4 normally closed in panel mounted units and from 1 normally open and 1 normally closed to 2 normally open and 2 normally closed contacts in base mounted units. **Clark Controller Co, 1146 E 152nd St, Cleveland 10.**

Circle 328 on Reader Service Card



Miniature two-gang switch . . . is applicable to a space of 1 x 1 x 1¼ in. The two snap-action switches can be operated individually or simultaneously from two directions. Contour shape actuator permits linear, rotary or rotary cam operation without auxiliary actuators. Its arm has built-in overtravel stop to prevent switch damage and prolong switch life. Overtravel of 0.125 min eliminates need for close tolerance cam designs. Unit is rated 10 amp at 125 v ac; 5 amp at 250 v ac; and ⅓ hp at 125/250 v ac. **Cherry Electrical Products Corp, PO Box 66, Highland Park, Ill.**

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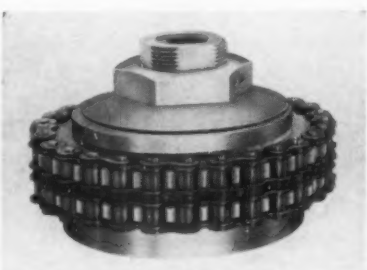

Overload protector . . . is a basic overload safety device combined with a roller chain coupling, half counter bored to fit unit's flange. Standard double width roller chain couples unit and coupling half. Adjusted with a torque wrench to a specific max torque load, device automatically disengages when set load is

continued, page 176

5 REASONS FOR SPECIFYING U.E. INDICATING TEMPERATURE CONTROLS

* **HIGH SENSITIVITY**...on-off differentials from ± .5° F with excellent repeatability

* **LOW COST** . . . list prices from $35.00 with generous quantity discounts

* **EASY MAINTENANCE** . . . thermal assemblies quickly replaced in the field with no loss of calibration accuracy

* **PROVEN DEPENDABILITY**... reliable liquid-filled measuring systems combined with simple service-proven components for accurate performance and long life

* **GREATER VERSATILITY**... many styles, ranges, sensing elements and switch characteristics permit hundreds of "custom-built" combinations

ALL PURPOSE

-150° to +650° F

A sensitive wide range unit with control point accuracy equivalent to individually calibrated instruments. 10" rotating scale permits unusual readability and close settings. Available with dual switches for controlling two independent circuits.

E 32N

E 36N

LOW COST... (800 Series) -150° to +650° F
Short dial spans of 50 to 200° F permit compact design only slightly higher in price than non-indicating controls. Available with dual switches.

HIGH TEMPERATURE . . . (900 Series) 0° to +1000°F
A NEW high temperature series with rugged stainless steel mercury filled thermal systems.

For the USUAL or UNUSUAL application, United Electric offers quality controls at economical prices.

E 65N

SPACE SAVING... -150° to +650° F
Skeleton design permits direct incorporation into equipment – saving cost of enclosure. Many models with dial spans of 50 to 200°F. Available with face plate for panel mounting.

E45N

SPECIAL PURPOSE . . . -150° to +1000°F
Shown here is a typical Special Purpose control used on medical equipment, such as baby incubators, etc. WHAT IS YOUR REQUIREMENT? Chances are one of our standard controls will satisfy your needs. If not, we'll put our 30 years' experience to work for you on special designs.

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Watertown 72, Massachusetts
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United Electrical Controls (Canada) Ltd. | United Sensor & Control Corp.
O'Connell Avenue Dorval, Quebec | Box 149 Glastonbury, Conn.

Write TODAY for complete specifications and price information on U. E. Indicating Temperature Controls, Attention Dept. W.

NAME_____ TITLE_____

COMPANY_____

ADDRESS_____

CITY_____ STATE_____

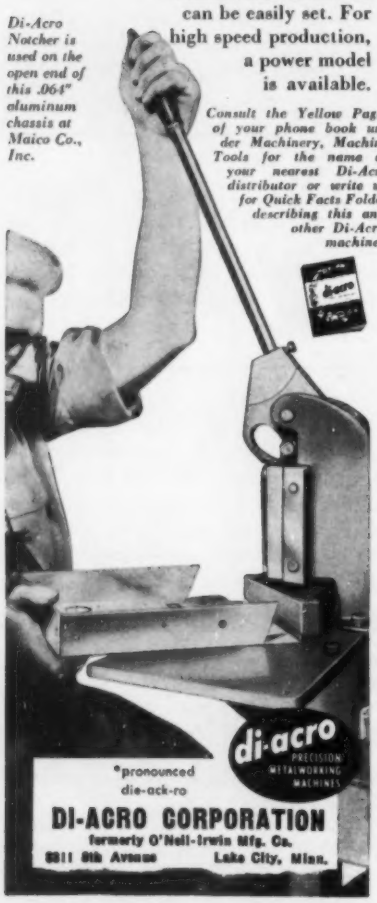
DI-ACRO*NOTCHER
Speeds Production, Saves Extra Operations on Chassis Work

"I use our Di-Acro Notcher for practically everything," says V. Johnson of Maico Co., Inc., Minneapolis manufacturer of hearing testing equipment. "This machine speeds production—*provides one operation notching* of cold rolled steel, brass, phosphorous bronze and aluminum up to 16 gauge thick. It's also used for notching fish paper, sponge rubber, 1/16" linen Bakelite and other circuit insulating materials that go into chassis for audio testing equipment."

The 4 ton pressure of this machine has the capacity to cut a 90° notch as large as 6"x6" in 16 gauge steel *in one operation.* Adjustable gauges mounted on work table are standard. Hardened and ground triangular ram assures years of precision. A clean cut, free from rough edges and burrs, is possible because blade clearance can be easily set. For high speed production, a power model is available.

Di-Acro Notcher is used on the open end of this .064" aluminum chassis at Maico Co., Inc.

Consult the Yellow Pages of your phone book under Machinery, Machine Tools for the name of your nearest Di-Acro distributor or write us for Quick Facts Folder describing this and other Di-Acro machines



*pronounced die-ack-ro

DI-ACRO CORPORATION
formerly O'Neil-Irwin Mfg. Co.
8811 8th Avenue Lake City, Minn.

Automatic reset timers . . . designed to delay an operation or operate circuit for preset time after remote pilot action, are driven by continuous running synchronous motors, said to up timing accuracy and simplify circuitry by eliminating motor shut-off switch. Can be externally wired for use with various pilot switches. One set of contacts, on delay, is connected to and operated by a solenoid, which eliminates need for external relay when momentary pushbutton pilots are desired. Each of three types is available with time range of 1 min., 3 min., 5 min., 1 hr or 5 hr, adjustable within range. Voltage is 120 or 240 v, 50 or 60 c (25 c not available); capacity load, 690 v-amp; switches, 120-600 v ac; motor wattage, 3 w; accuracy, ±1%, total dial range; min setting, two dial graduations or 2 sec out of 60-sec range, or at zero position. Switches are independent of motor and can be wired independently up to 600 v. **Paragon Electric Co Inc, Two Rivers, Wis.**

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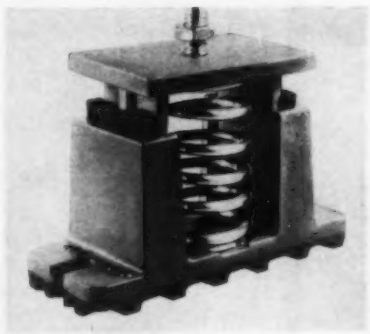

Spring mounting . . . is an isolator using a single helical coil steel spring as cushioning medium. Stops vibration and shock and simplifies installations. Load-carrying capacities range from 50 to 540 lb, made possible by selection of four different springs which can be inserted into isolator housing. Cast semi-steel housing, measuring 2¾ x 3¼ x 5⅛ in., has an access port on each side, which enables spring to be changed. **Korfund Co Inc, Shock and Vibration Div, 19 G Cantiague Rd, Westbury, LI, NY.**

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HERBERT W. WESTEREN, Hayes Ass't Director of R & D, tells about the Hayes way to solve

VACUUM SINTERING

TEST IT! You bring your test compacts to the Hayes lab. where they can be heat treated in production-scale vacuum equipment under varying time/temperature/vacuum conditions. Here you prove BEFORE PURCHASE that your work is right for vacuum sintering, whether it's stainless steel, tungsten carbide, cermets, refractory metals, glass preforms, or other ferrous or non-ferrous materials. You also determine whether or not you need atmosphere-protected presintering —a frequent requirement in this type of processing.

DUPLICATE RESULTS! Next you work with our furnace applications engineers to obtain the exact VACU-MASTER® design you need, taking in consideration: size of workpieces, amount of production, fixturing, temperature range, degree of vacuum, heating and cooling cycles, type and volatility of sinter binder, evolved gases, etc. The lab-proved procedure takes form in a Vacu-Master design engineered for your job — the *right* heating elements and power, the *right* size of heating and cooling chambers, the *right* pumping system, the *right* controls and instrumentation.

Model VAC-50 Series Cubicle Vacu-Master, compact cold-wall vacuum furnace.

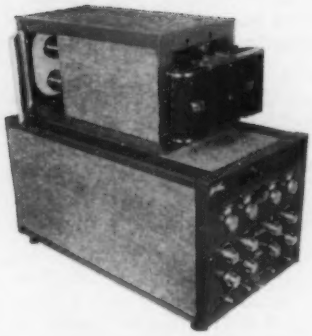
RESULTS? GUARANTEED! Hayes Vacu-Masters are right now sintering stainless steels at 2,150°F to 2,300°F (depending on size and analysis of work). They're sintering tungsten carbides at 3,000°F to 3,200°F. They're sintering glass preforms and other electronic components. They're treating titanium, hafnium, zirconium . . . AND THEY'LL TREAT YOUR WORK RIGHT!

TRY HAYES! Take advantage of our store of metallurgical know-how and experience-proved furnace designs. Write for VACU-MASTER vacuum furnace Bulletins 6010-B, 5709-B, 5709-A . . . or ask for a date to visit our lab. C. I. Hayes, Inc., 958 Wellington Ave., Cranston 10, R. I.

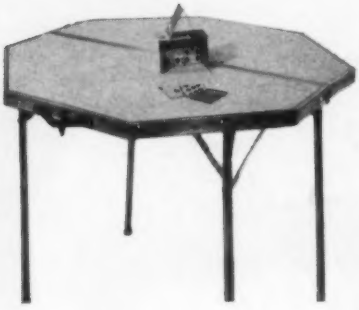
C. I. HAYES, INC.
Established 1905

ELECTRIC FURNACES

It pays to see Hayes for metallurgical guidance, lab. facilities, furnaces, atmosphere generators, gas and liquid dryers, pHayes-Master (TM) power controls, induction generators.



Masland Duran
CLAD
vinyl finish



On just about any product this built-in finish reduces manufacturing costs...boosts saleability

Take the matter of costs. Since Masland Duran Clad is an *integral* finish, you can work with pre-finished parts. That means you can often do away with the need for baking and spraying. No new processing equipment needed, either. This colorful, handsomely designed vinyl can be permanently laminated to metal . . . and cut, crimped, drilled or deep drawn without distortion or marring. As for saleability . . . there isn't anything that excels color-bright, easy-to-clean Clad for attracting immediate and favorable attention to your product. For samples, mail this coupon.

Industrial Products Division

THE MASLAND DURALEATHER CO., Dept. PE-L, Philadelphia 34, Pa.

SEND FOR SAMPLES TODAY

The Masland Duraleather Co., Dept. PE-L,
Amber & Willard Sts., Philadelphia 34, Pa.

Please send information and samples of Clad.

Name_____ Title_____

Company_____

Street_____

City_____ Zone_____ State_____

Here's 0.1° Sensitivity at a Competitive Price!

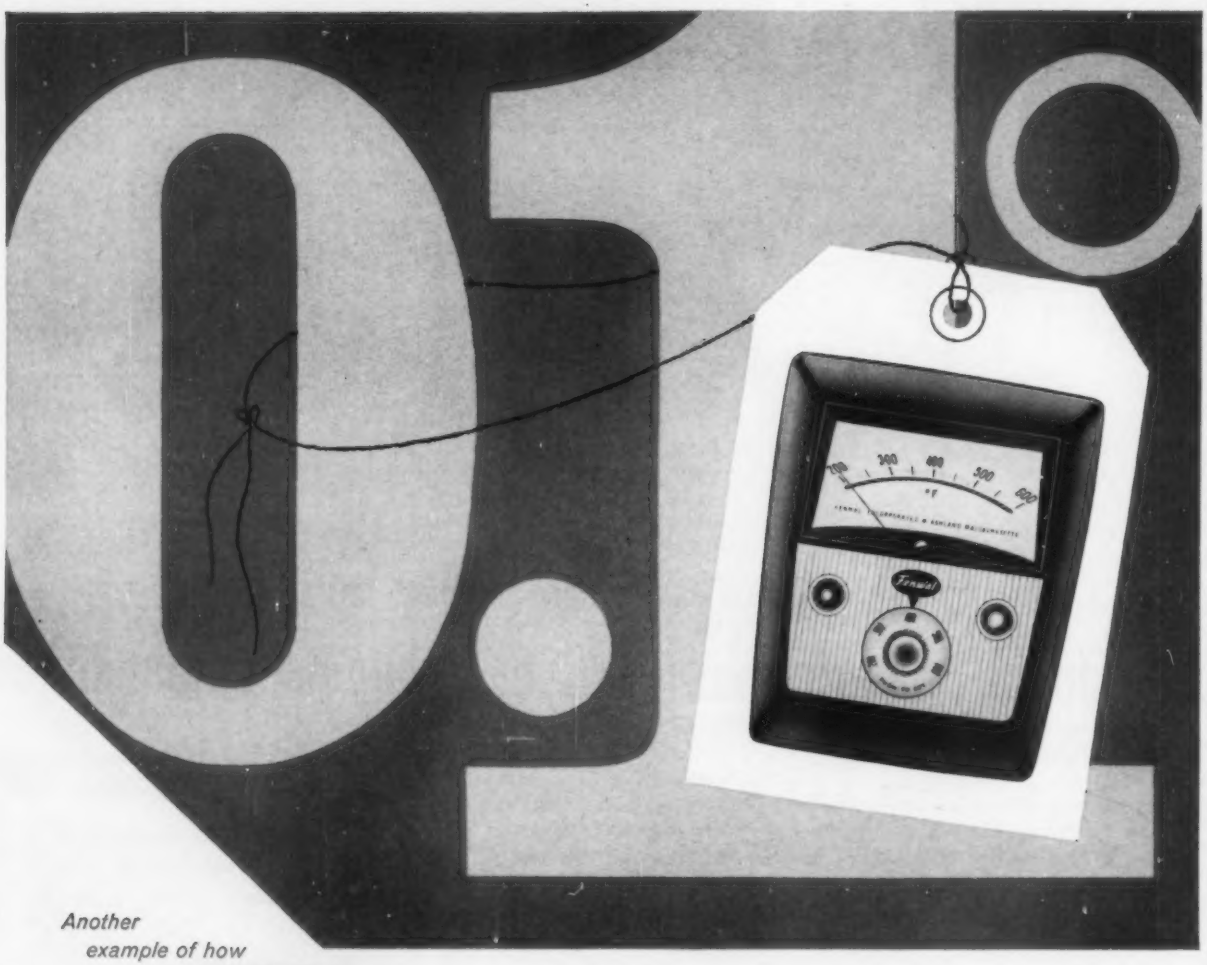
... Fenwal's New "561" Temperature Controller

The new "561" indicating controller responds to temperature changes of 0.1° or less! And is yours at a competitive price! These two features alone make it an instrument you should investigate... but there's more!

You can choose from five standard temperature ranges . . . within the span of −50 to 600°F. Furthermore, scales start and end within *your* ranges, permitting larger graduations, better legibility, easier readout. And control and indication are separate but simultaneous. *Should your indication fail the "561" will continue to control with complete accuracy.*

This precise instrument gives unvarying performance. Its indication and control will not vary with fluctuations of input voltage nor changes in ambient temperature. It offers the option of either ON-OFF or proportional control . . . has 10 AMP/120 VAC relay capacity. Smartly styled to complement modern industrial machines and interiors, *the "561" offers you all these extras at a competitive price.*

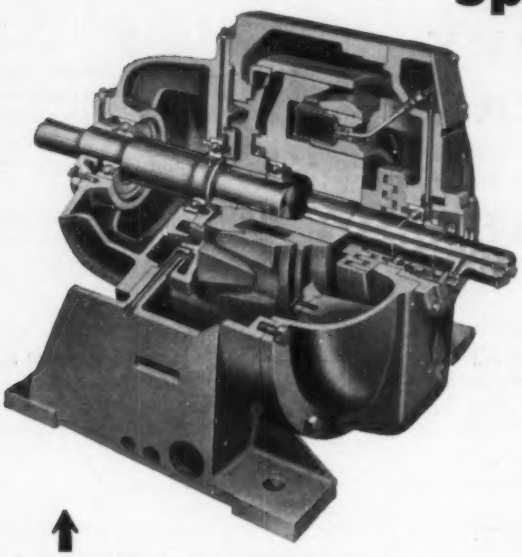
A Fenwal engineer will be glad to supply information on the "561", or any other temperature control in Fenwal's broad line. Write Fenwal Incorporated, 31 Pleasant Street, Ashland, Massachusetts.



Another example of how

Fenwal CONTROLS TEMPERATURE . . . PRECISELY

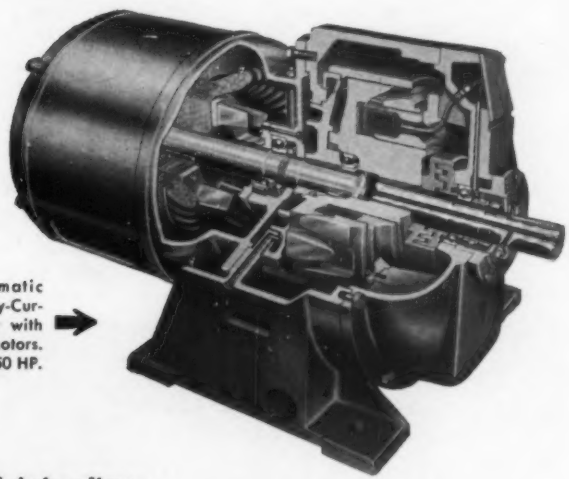
The BEST Solution to Difficult Speed Control Problems—



Dynamatic Liquid-Cooled Couplings provide infinitely adjustable speeds for nearly every application from 3 to 150 HP. Note the absence of slip rings, brushes, and commutators. Heavy-duty types with capacities up to 5,000 HP are also available.

EATON DYNAMATIC®

LIQUID-COOLED EDDY-CURRENT COUPLINGS and DRIVES



"Dynaspede" Drives are Dynamatic Liquid-Cooled, Stationary-Field Eddy-Current Couplings mounted integrally with standard, D-flange, squirrel cage motors. Available in capacities from 3 to 150 HP.

Here's Why—

Dynamatic Liquid-Cooled Couplings and Drives provide infinitely adjustable speed from a constant speed source—or constant speed from a variable speed source. They operate on standard alternating current. Rotary power is transmitted through the coupling by an electromagnetic reaction between the driving and driven members of the unit—there is no mechanical contact of rotating members to cause wear and require adjustment or replacement.

A wide range of standard and special control features may be obtained from a remotely-mounted electronic control system. Infinite speed adjustment, constant speed control, on-off clutch control, torque limit, acceleration control, inching, and threading are a few of the many functions available. The addition of an eddy-current brake to standard couplings or drives provides smooth, cushioned stops and controlled deceleration.

Liquid-Cooled Dynamatic Couplings and Drives deliver more horsepower than other types of the same physical size, thus conserving space in a busy machine area. Efficient heat dissipation permits continued operation at low speeds, or stall with full load.

Completely enclosed, Dynamatic liquid-cooled units are protected from dust, dirt, and other atmospheric impurities. Dynamatic design involves no brushes or slip rings; there is no possibility of arcing. With simple modification these units can be made explosion-resistant for hazardous applications.

Infinitely Adjustable Speeds from AC Power

★

Smooth, Quiet Operation from Cushioned Starts

★

Wide Range of Control Functions

★

No Slip Rings, Brushes or Commutators

★

Completely Enclosed Design

★

Greaseable Bearings

Send for Our New Illustrated Bulletin.

EATON

DYNAMATIC DIVISION
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CIRCLE 203 ON READER SERVICE CARD 179

for pumps as individual as a fingerprint!

SPECIFY NORTHERN NITRALLOY PUMPS

Select a Pump Sized for the Exact Capacity and Pressure of Your Application

39 pump sizes	.24 to 145.6 GPM	50 PSI
38 pump sizes	.24 to 145.2 GPM	100 PSI
31 pump sizes	.23 to 121.0 GPM	200 PSI
27 pump sizes	.22 to 93.1 GPM	300 PSI
27 pump sizes	.22 to 91.5 GPM	400 PSI
19 pump sizes	.21 to 57.8 GPM	600 PSI
15 pump sizes	.19 to 44.7 GPM	800 PSI
14 pump sizes	.17 to 43.5 GPM	1000 PSI
11 pump sizes	.14 to 15.5 GPM	1500 PSI
6 pump sizes	.59 to 14.0 GPM	2000 PSI

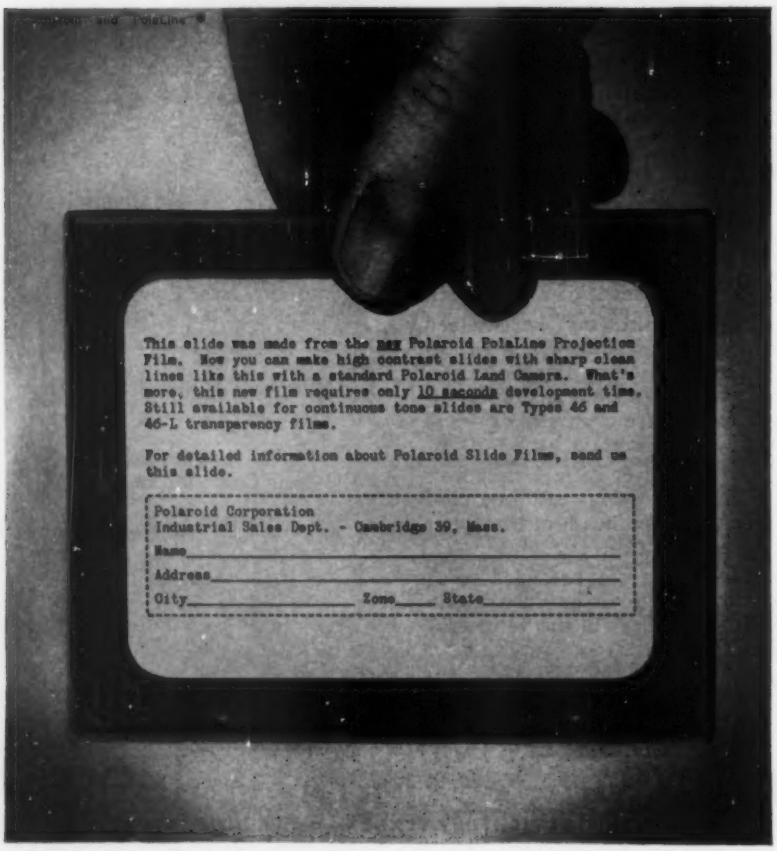
Please write today for free catalog and engineering data

Northern Ordnance Incorporated

Subsidiary of NORTHERN PUMP COMPANY

Minneapolis 21, Minnesota

CIRCLE 84 ON READER SERVICE CARD


This slide was made from the NEW Polaroid PolaLine Projection Film. Now you can make high contrast slides with sharp clean lines like this with a standard Polaroid Land Camera. What's more, this new film requires only 10 seconds development time. Still available for continuous tone slides are Types 46 and 46-L transparency films.
For detailed information about Polaroid Slide Films, send us this slide.
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Address
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NEW MATERIALS

Acrylic molding powder . . .

is available in a new grade said to offer double the highest impact strength of other high-impact acrylics. Also is reported to have high degree of transparency in natural color which increases range of color possibilities and adds to luster and color depth of molded parts (molded parts with wall thicknesses of ⅛ in. or less, in natural color, are transparent enough for observation of liquid or power levels in molded containers). Comes in wide range of standard colors, as well as natural, for injection molding or extrusion of sheets and shapes. **Rohm & Haas Co, Washington Sq, Philadelphia 5.**

Circle 333 on Reader Service Card

Tungsten disulfide . . .

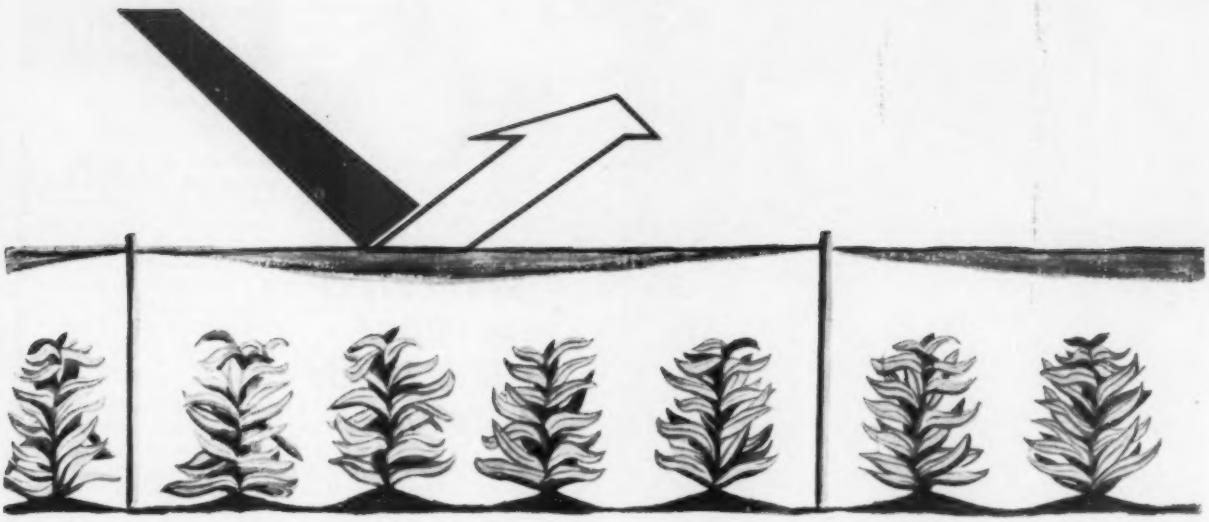
useful as a high-temperature lubricant and catalyst, is now available in commercial quantities. Chemical is a synthetically produced, soft, grayish-black powder that reportedly has high oxidation resistance and excellent lubricating properties. Can be used in solid-film form or added to suitable carriers as an effective lubricant in wire drawing, metal forming, cutting and working and in valves, gears and bearings. Lubricating properties exhibited are similar to molybdenum disulfide and graphite. However, in the area of oxidation resistance, tungsten disulfide loses only 1.2% of its sulfur content after 2-hr exposure in air at 800 F, whereas molybdenum disulfide loses 77% of its sulfur content under same conditions. **Chemical & Metallurgical Div, Sylvania Electric Products Inc, Towanda, Penna.**

Circle 334 on Reader Service Card

Tellurium-bearing steel . . .

reportedly can be machined 3½ times faster than standard screw machine steel, B1112, and roughly twice as fast as leaded grades. During tests, speeds over 600 sfm were reached with small amount of tool wear. Available from two sources in hot rolled and cold finished bar at $15 per ton premium over leaded grades. According to developer, Inland Steel Co, present limited supply of the rare element will restrict production of tellurium-bearing steel even though a few hundredths of 1% by weight is needed to obtain benefits it contributes to machinability of steel. New steel has equivalent of a built-in lubricant and makes small chips in cutting process

continued, page 183



Stop Heat Cold With Any Flexible Material—Aluminated

Tobacco men are guessing that Connecticut leaf fields will have a new look next spring. They're betting on shiny, metallic colored shade nets to replace familiar white. Tender tobacco plants need even-temperatured living to stay healthy and spot free. The high reflectivity is expected to even out temperature variations and prolong net life.

Alumination—a new process by Thermo-Chem for impregnating ANY flexible material with aluminum—is behind the speculation on the changing scene. Alumination increases utility and widens useful temperature range by giving up to 20 times more heat (and cold) reflectivity.

Alumination doesn't crack, peel off, discolor. It won't lose its temperature-reflecting ability. And it adds strength and abrasion resistance without excess weight.

Other familiar scenes will change, too. Pipe lines insulated with Aluminated paper. Filter systems lined with Aluminated linen. Hot conveyor belts of Aluminated ordinary duck. The Alumination process adds a thousand new materials for use in hot places.

Take your pick.

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Advanced models of Dymo Tapewriter® are here now!

Professional raised-letter labels made on-the-spot for every type of application. Solve identification problems with industry's most versatile labeling system. Three *all new* DYMO Tapewriters are now available... Model M-11 for making metal labels, Models M-22 and M-33 for self-sticking plastic labels. Tapes available in 10 coding colors. An entirely new line of two-color tapes... plus a revolutionary contrasting aluminum tape!

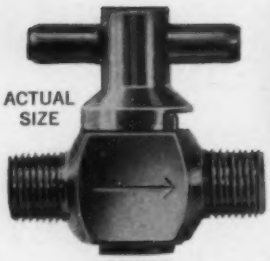
Tapewriters start at $39.50. Ask your distributor or write for sample and literature today.

Dymo Industries, Inc. / Dept. PE-11 / 2950 7th St. / Berkeley, Calif.

(TAPE SHOWN ACTUAL SIZE)

IDENTIFICATION SYSTEM

182 CIRCLE 206 ON READER SERVICE CARD



SERIES 9500

CIRCLE SEAL MINIATURE PLUG VALVE

ABSOLUTELY LEAKPROOF ...EFFORTLESS CONTROL

Positive sealing from high vacuum to 2000 psi. Male or female connections in ⅛" or ¼" sizes. Brass or 303 stainless.

Miniaturized at no sacrifice in quality, the Circle Seal 9500 Series is ideal for application in instrumentation, inert gas test stands, hydraulic clamps, jacks, etc. The convenient "T" handle with 90° actuation provides effortless opening and closing. The handle is color coded for various gases and liquid service requirements. The visual indication provided by the "T" handle can be used as a metering device by turning the handle various degrees from full-on to full-off. "O"-Ring seals virtually eliminate wear. When required, simple repair is effected by replacing three "O"-Rings without removing valve from the line.

CIRCLE SEAL PRODUCTS CO., INC.
2181 East Foothill Blvd.,
Pasadena, Calif.

CIRCLE SEAL
precision valves

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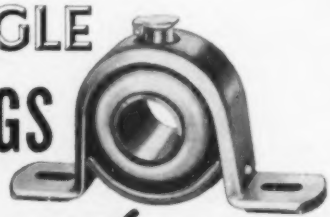
TRIANGLE BEARINGS with *Engineered* INDIVIDUALITY



Triangle fits the bearing to the application. Whether you can use a standard, like the Pillow Block above, or need a special such as the Pedestal or Clamshell Bearings shown below, your particular bearing problem receives the individual attention best assuring cost reductions — quality improvements.

SELF-ALIGNING . . . SELF-LUBRICATING SLEEVE-TYPE PILLOW BLOCKS

The widest selection of mountings available — functionally designed, efficiently produced. Experienced sales engineers available to help you anywhere. Phone or write for descriptive literature.

TRIANGLE MANUFACTURING CO.
730A Division St. Oshkosh, Wisconsin

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which fall away from tool and so reduce heat buildup. Hot rolled bar from **Inland Steel Co, 30 W Monroe St, Chicago 3.** Cold finished bar from **La Salle Steel Co, 1420 150th St, Hammond, Ind.**

Circle 335 on Reader Service Card

Fluorosilicone compounds . . . are said to be characterized by outstanding solvent resistance, plus resistance to heat, cold and oxidation. Differ from ordinary silicones in that they contain fluorine groups instead of some of their hydrogen groups. Can be produced in wide range of forms—rubbers, lubricants, capacitor fluids, sealants, compressor oils and hydraulic fluids. Fluids are reported to have good lubricity (better than previously available silicones), stability over a wide temperature range and several often high electrical properties. Rubbers are fully commercial and priced at $12 per lb (down from $30 when first introduced). Others, now in substantial pilot production, carry "introducing price" tags of $25 to $46 per lb. **Dow Corning Corp, Midland, Mich.**

Circle 336 on Reader Service Card

Nylon pressure tubing . . . can replace more expensive seamless copper, extruded aluminum, welded stainless and seamless steel tubing in most types of hydraulic-pneumatic service. Weighs 1/7th that of copper tubing; is available in 1000- and 2500-psi grades; withstands temperatures from −40 to 185 F; and is resistant to corrosive oils, greases, dilute acids and alkalies. Its flexibility eliminates pre-bending and need for flexible couplings or intermediate fittings. Also requires no deburring and is odorless, non-toxic and fungus-resistant. Available in ⅛- to ½-in. sizes. **Garlock Inc, Palmyra, NY.**

Circle 337 on Reader Service Card

Heater-embedded plastic parts . . . lower assembly costs, since fastening means are not required for attaching separate heaters. Electric heating elements are molded integral with the reinforced plastic parts. Among other advantages claimed are that heating elements remain permanently aligned and protected within parts; reliability is increased because there are no fasteners or adhesives to loosen under shock and vibration; bulk and weight are reduced, etc. Surface tempera-

continued, page 184

NEW BLH MICROMINIATURE AMPLIFIER IS SMALLEST, MOST RELIABLE UNIT AVAILABLE AT ITS PERFORMANCE LEVEL

Top Performance in Miniature . . . less than one cubic inch of:

Power—gains of 10, 20 and 200, with other gain values available.

Stability—better than ±15 microvolts referred to the input and to a given temperature, including all effects of use and environment.

Capability—operating temperature range from −100°F through 350°F with no sacrifice in output at either extreme. Vibration and shock resistance are transistor-limited only.

Linearity—terminal linearity better than ±.05% of full scale.

Diversity—many applications in ground support systems, integral transducer amplification, analog computers, low level commutations, plus many other electronic products and systems.

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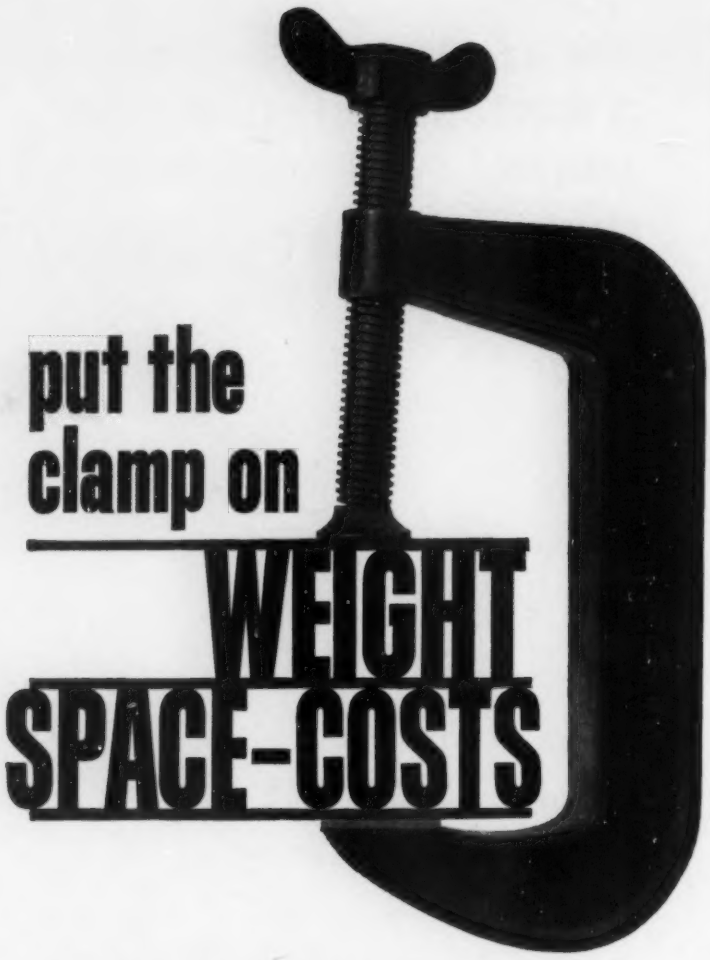
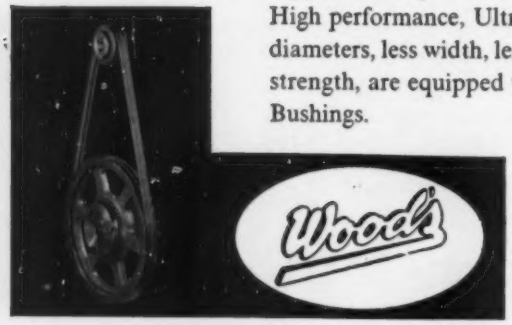


SPECIFY WOOD'S ULTRA-V DRIVES

Wood's Ultra-V Drives offer tremendous savings over conventional v-belt drives . . . up to 50% in space, 27% in weight, 30% and more in costs. And there are savings on bearings, bases and housings. Greatly improved belt materials and belt construction assure unmatched dimensional stability, amazing strength, greater grip, added support and equalized load for tension members. High performance, Ultra-V sheaves have smaller diameters, less width, less weight and tremendous strength, are equipped with famous "Sure-Grip" Bushings.



WRITE FOR BULLETIN 9102

T. B. WOOD'S SONS COMPANY • CHAMBERSBURG, PENNSYLVANIA

UV/2361 ATLANTA • CAMBRIDGE • CHICAGO • CLEVELAND • DALLAS

tures as high as 600 F reportedly can be attained without delamination. **Riverside Plastics Div, Bischoff Chemical Corp, 220 Miller Rd, Hicksville, NY.**

Circle 338 on Reader Service Card

Spring steel . . .
can be supplied in widths to 48 in. and in any desired length. Steel is cold-rolled, hardened and tempered with a tensile strength of 170,000 psi and Rockwell hardness of 38. Available in grey hardened finish only. **Sandvik Steel Inc, 1702 Nevins Rd, Fair Lawn, NJ.**

Circle 339 on Reader Service Card

Self-lubricating bearing bronze . . . for bushings, bearings, seals, etc, is available in range of diameters up to 5 in., in standard lengths of 13 in. or cut to specification, and in solid or hollow bar. Produced by continuous cast process that is said to effect an unusually fine dispersion of lead, upping alloy wear life and physical characteristics. Properties include: tensile strength, 16,300 psi; yield strength, 9000 psi; elongation in 2 in., 10; Brinell hardness, 30; and machineability, over 100 (compared with free cutting brass). Can be specified in sizes and shapes close to those required for finished components, thus reducing machining time, scrap and tool wear. **American Smelting & Refining Co, 120 Broadway, New York 5.**

Circle 340 on Reader Service Card

Polyethylene formulation . . .
produces glossy coatings with low coefficient of friction. Contains a special slip additive that withstands up to 600-F melt temperature required in extrusion coating. Differs from former slip additives that tended to volatilize or decompose at extrusion-coating temperatures, making it necessary to lower coefficient of friction in coatings by giving them a matte finish or by dusting or spraying them with a slip agent after extrusion. New formulation is said to offer uniform drawdown, low neck-in, low edge variation and good adhesion. Has a nominal melt index of 3.5 and a nominal density of 0.921. In tests, min sealing temperature of 1-mil coatings on 40-lb kraft paper was approx 300 F. **Eastman Chemical Products Inc, Sub of Eastman Kodak Co, 260 Madison Ave, New York 16.**

Circle 341 on Reader Service Card

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MT. VERNON FILES

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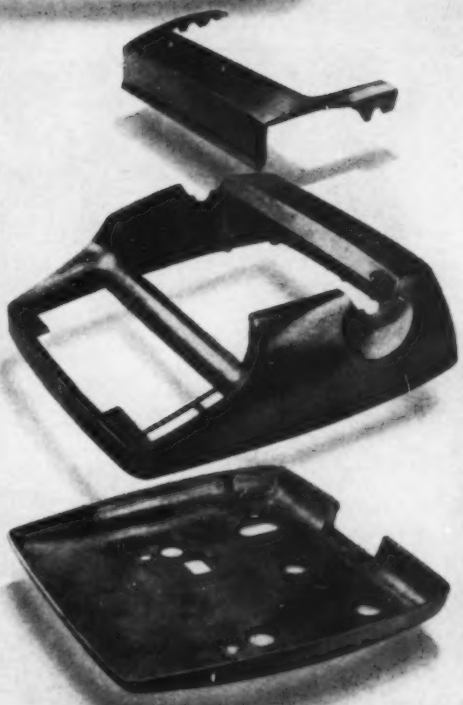
This truly revolutionary IBM SELECTRIC typewriter is probably the most important breakthrough in office technology since the invention of the typewriter itself.

It is a brilliant example of engineering, workmanship and the imaginative use of materials and processes. Contributing to the beautiful appearance — and much lighter overall weight — are the 3 Mt. Vernon aluminum die castings that comprise the housing. They weigh only 5½ lbs.

As with IBM to whom Mt. Vernon has been a reliable supplier for several years, we also offer you our fourfold services and coordinated facilities for precision zinc and aluminum die castings.

New IBM Electric Typewriter dressed up in Die Castings by MT. VERNON
IBM's "NEW LOOK" Selectric with MT. VERNON Die Castings
1958
1959

We may be the "reliable supplier" you need to help you improve your products. Why not get in touch with us and talk it over? Our field salesmen are waiting for your call.



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Stamford, Connecticut

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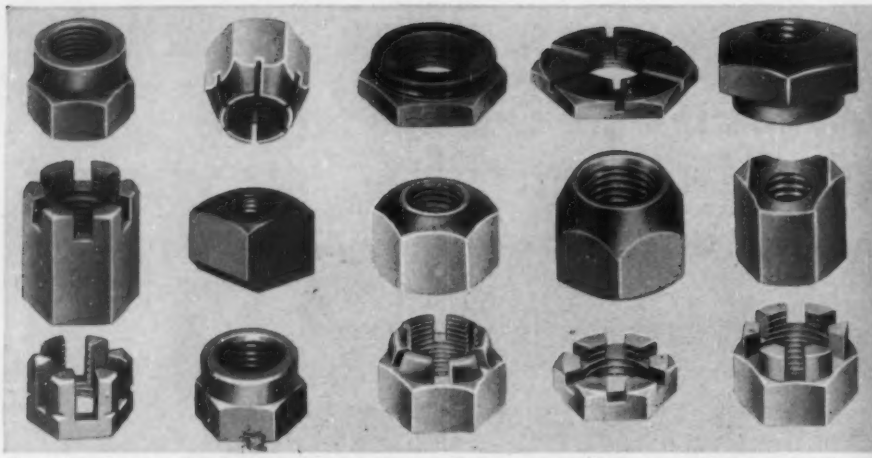

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7/16" — 4 1/4" across flats

As the largest specialized nut manufacturer in the world we are constantly developing new methods and products for this phase of assembly in industry. Our batteries of special high speed multi-spindle, automatic machines make possible fast and accurate production of hexagon nuts of non-standard height and special shape from carbon or alloy steel, Naval Bronze or other non-ferrous metals, also AN310 through AN335 as per latest Airforce specifications.

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Send for 16-page condensus catalog, it includes complete specifications, as well as engineering data.

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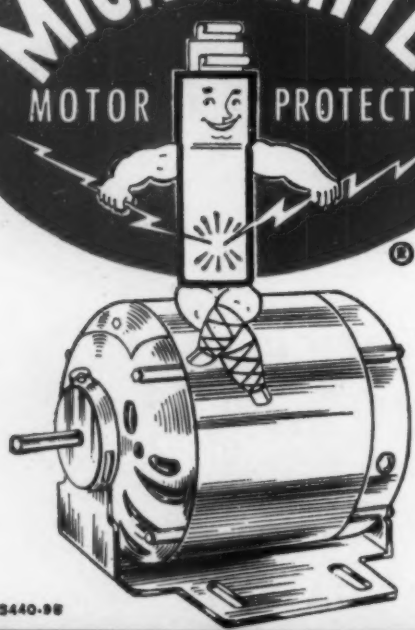
MIGHTY MITE

MOTOR PROTECTORS



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CYLINDERS
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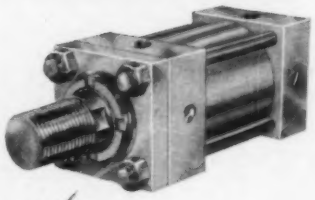

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ESTABLISHED 1918
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EQUIPMENT

Dynamic load . . .
measures internal ac impedance of power supplies at frequencies from 20 cps to 1 mc for dc power supply voltages up to 32 v. Measurements can be taken with dc power supply current between 50 ma and 2.5 amp or with ac current up to 4 amp peak-to-peak. Meters indicate peak-to-peak supply, ac output current, power supply, dc output current and power supply dc output voltage. Front panel terminals are provided for connecting a signal generator for source of ac test signals and ac voltmeter to measure amplitude of power supply ac output voltage, and an oscilloscope to monitor signal distortion. Unit measures 9 x 7 x 12¼ in. and weighs 15 lb. Its power requirements are 105 to 125 v ac, 60 to 400 cps at 0.25 amp. Priced at $950 with delivery in 30 to 60 days. **Electronic Engineering Co of California, 1601 E Chestnut, Santa Ana, Calif.**

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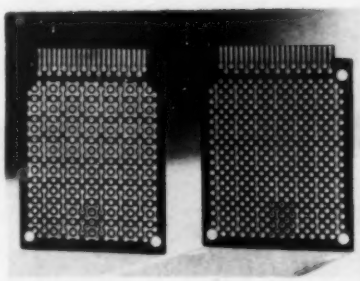
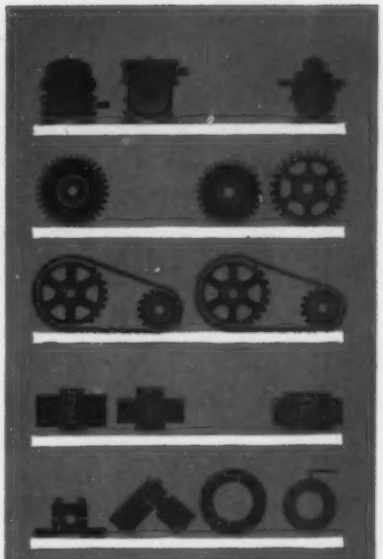


Matrix board . . .
which aids design of prototype printed circuit devices, carries universal ring-and-dot pattern of metallized runs, pads and through-plated holes on a glass-ceramic substrate. Each corner has a chassis mounting hole and one end is a 22-contact plug section. Once prototype design is set, board can be used economically in production. Accepts all types of components, including transistors, and is designed for use in ambient temperatures of up to 482 F. Reportedly will not warp, bow, sag, swell, rot, delaminate, burn or absorb moisture, oils or organic solvents. Measures 4½ x 5½ x $\frac{1}{16}$ in. and is available from stock at $9.95. **Corning Glass Works, Bradford, Penna.**

Circle 343 on Reader Service Card

Transistor evaluation kit . . .
contains six 2N782 epitaxial mesa (PNP) transistors, 12 applications circuits and a reference folder with electrical and mechanical data. The

continued, page 191



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Charles Bond's large factory and distributor stocks provide an ideal "instant source" for Power Transmission Equipment for today's replacement and design applications. Frequently, the use of a Bond stock component eliminates the need to create a new component—with attendant delay and expense. When required Bond does create special units to your specifications.

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Series "A"
Heavy Duty
High Speed

INDEX TABLE

by CMC

The one unit that does bigger jobs better . . . Series "A" High Speed Index Table is quality to the highest standards . . . provids extreme accuracy of .001 on a 28" diameter . . . efficiently handles loads of 24,000 inch pounds, and over, with outstanding accuracy and maintains zero backlash in dwell position with a high-speed jerk-free operation . . . enables designers to make full use of modern high speed equipment.

With the New Series "A" Index Table You Get:

- **Timken bearing near outside diameter of cam follower plate for greatly increased stability**
- **Supports dial plate load of 18,000 lbs.**
- **Machined housing surface for mounting tooling plate and permitting shaft mounted speed reducers to be fitted direct**
- **Immediate adaptability to dial plate of your choice**
- **Hollow output shaft enables air, fluids, coolants or additional tooling to be brought directly to center of work area**
- **Hardened, MACHINE GROUND tool steel cam; precision bearings; MACHINE GROUND critical components**

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CMC

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Compare for Yourself

For versatile, economical and *positive* fastening, specify Driv-Lok. Give us a call, or write for your free catalog today.

Standard Type A Shear-Proofs (shown) are stock. Samples available on request.

MINIMUM SHEAR VALUES IN POUNDS			
Diameter	Slotted Spring Pins	Coiled Spring Pins HEAVY DUTY	Shear-Proof DRIV-LOK PINS
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1/8"	2100	1840	3690
5/32"	3000	2880	5720
3/16"	4400	4140	8240
1/4"	7700	7360	14720
5/16"	11500	11500	22960
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7/16"	20000	22540	45000
1/2"	25800	29440	58900

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1001 USEFUL BUYS!

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Complete with leather case. Measures Angles, Radii, Circles, Linear—in both decimal inches and millimeters. Used to check layouts, machining on tools, dies, gauges; to check threads, chamfers, wear on cutting tools, etc. Handy! Fast!
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Recover tools and parts from inaccessible spots; hold work in place; rid shop floor of metal fragments, pins, etc. Use this horseshoe shape 5 lb. war surplus Alnico V-Type Magnet—tremendous lifting power, over 125 lbs. Rated at 2000 Gauss. Lots of fun, too—use for "fishing" the bottoms of lakes, rivers, ocean, etc.—retrieve motors, fishing tackle, metal valuables.
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nomenclature		basic		heavy duty	inverted		bowed		beveled		bowed e-ring	prong-lock®
series no.		5000 N5000	5100	5160	5008	5108	N5001	5101	5002 N5002	5102	5131	5139
application		Internal for Housings, Bores	External for Shafts	External for Shafts	Internal for Housings, Bores	External for Shafts	Internal for Housings, Bores	External for Shafts	Internal for Housings, Bores	External for Shafts	External for Shafts	External for Shafts
size range	in.	.250 – 10.0	.125 – 10.0	.394 – 2.0	.750 – 4.0	.500 – 4.0	.250 – 1.500	.188 – 1.500	1.0 – 10.0	1.0 – 10.0	.110 – 1.375	.092 – .438
	mm.	6.4 – 254.0	3.2 – 254.0	10.0 – 50.8	19.0 – 101.6	12.7 – 101.6	6.4 – 38.1	4.8 – 38.1	25.4 – 254.0	25.4 – 254.0	2.8 – 34.9	•

function		for radial assembly				self-locking types					
nomenclature		crescent®	e-ring	interlocking	reinforced e-ring	circular self-locking			grip-ring	triangular self-locking	triangular nut
series no.		5103	5133	5107	5144	5115	5105	5005	5555	5305	5300
application		External for Shafts	External for Shafts	External for Shafts	External for Shafts	External for Shafts	External for Shafts	Internal for Housings, Bores	External for Shafts	External for Shafts	With Threaded Screw
size range	in.	.125 – 2.0	.040 – 1.375	.469 – 3.375	.094 – .562	.094 – 1.0	.094 – 1.0	.312 – 2.0	.079 – .750	.062 – .438	•
	mm.	3.2 – 50.8	1.0 – 34.9	11.9 – 85.7	2.4 – 14.3	•	•	•	2.0 – 19.0	•	•

Truarc retaining rings are precision-engineered fasteners which simplify design, speed production and reduce material, machining and assembly costs. They may be used to retain components on shafts and in bores and housings .040" to 10" dia. – and rings as large as 40" dia. have been developed for special applications! Truarc rings are installed in easy-to-cut grooves and self-locking types are available which do not require any preparatory machining. Altogether, there are 50 functionally different types . . . some with as many as 98 sizes . . . in 6 metals and 13 finishes.

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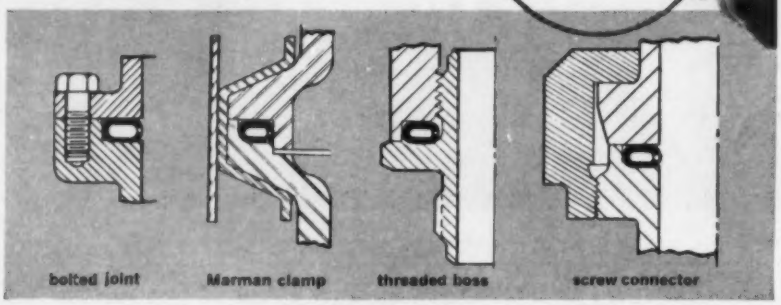

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form positive, permanent, non-corrosive, static seals under pressure extremes from 10^{-6} mm Hg to 100,000 psi (or the ultimate compression stress of the metal itself) and temperatures from −452° to 3000° F. Available in various metals and coatings (including Teflon** and silver) ¼" O.D. to any size and configuration. United also makes non-vented and pressure-filled O-rings.

United Metallic "O" Rings, manufactured by United Aircraft Products, Inc., Box 1035, Dayton, Ohio.

See United Metallic O-Ring Catalog in Sweet's Product Design File or write for Free Handbook

*Patents 2,809,269; 2,837,360
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3

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epitaxial mesa units are for high speed switching applications in the millimicrosec range. Among circuits included with kit are a high-speed current switch, a 20-mc astable multivibrator, a 5 mc/s computer block source and a three-stage DCTL circuit. The six transistors, plus kit material, are priced same as that of three units, representing a $19.65 saving over cost of comparable transistors purchased individually. **Sylvania Electric Products Inc, 100 Sylvan Rd, Woburn, Mass.**

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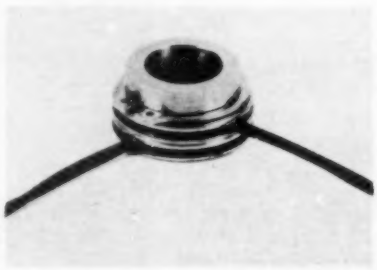
Semiconductor component kits . . . contain working quantities of spheres, washers, rings, pellets, base tabs and foils of various alloys, claddings and combinations. Nine different sphere kits are available, comprising six different items, ranging in price from $18.50 to $47.50 (specific price of any kit depends on quantity required, type of alloy and/or degree of purity). Four kits of specialized stampings are available, along with three kits of foils and clad metals. Elements include gold, tin, lead, selenium, indium, silver, aluminum and alloys of these materials. Special kits can be furnished for microwave devices and tunnel diodes. **Semi-Alloys Inc, 20 N MacQuesten Pkwy, Mt Vernon, NY.**

Circle 345 on Reader Service Card



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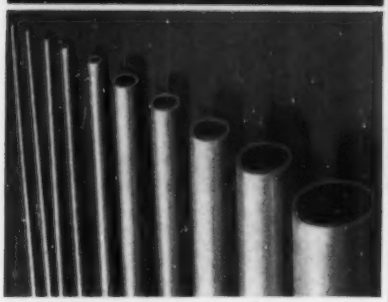

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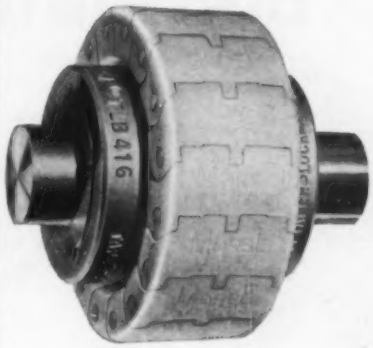

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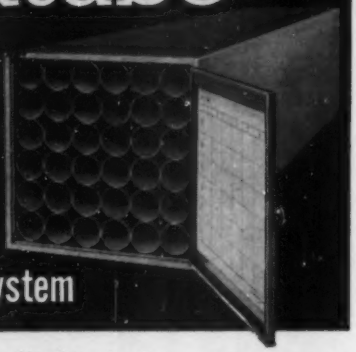

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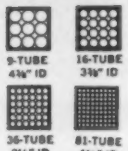

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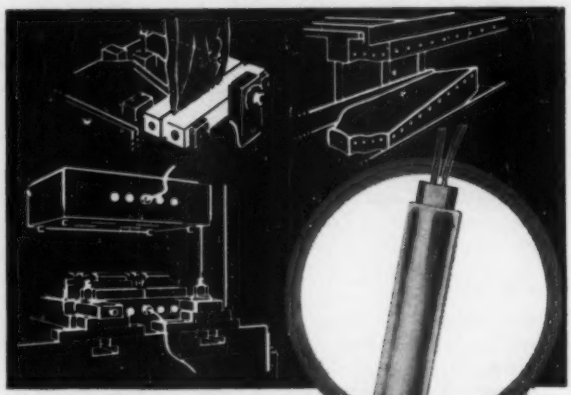

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DESIGN LITERATURE

Engineered Castings

G L COOK. McGraw-Hill Book Co, Inc, 330 W 42 St, NY. 9¼ x 6¼, 257 pp. $7.50.

This book is taken from a series of talks given by the GE Foundry Dept for GE engineers, manufacturing specialists and purchasing people. Although it covers the castings field generally without going into too much detail, much of the information is directed specifically towards design.

Besides the usual treatment of the casting process, it compares all the production processes and tells when and where to choose castings. It also shows how to select materials, and how to design castings.

The last section, how to buy castings, is unusual. It tells what engineering help you can expect when you buy castings and where a vendor can help or hinder design.

Introduction To Mechanics

IRVING J LEVINSON. Prentice-Hall, Inc, Englewood Cliffs, New Jersey. 6 x 9, 315 pp. $10.60.

Purpose of this book is to evolve an understanding of the basic laws of statics and dynamics for the reader who has no prior knowledge of the subject.

Basic algebra and trigonometry are the only prerequisites and the author includes a brief review of trigonometry in the first chapter as an aid to anyone who is rusty in mathematics. Calculus is not used in the text. Topics included are: a discussion of the earth as a rotating body, the Coriolis acceleration, shear and moment diagrams, belt and disk friction, fluid statics, elastic impact, balancing and a brief introduction to vibrations.

Engineering Management and Administration

VAL CRONSTEDT. McGraw-Hill Book Co, Inc, 330 W 42nd St New York 36, NY. 5¼ x 8, 345 pp. **$8.50.**

Modern tools, policies, and practices used to manage engineering departments more efficiently and effectively are defined and described in this handbook for today's engineers. It brings together all those business matters—as they affect the engineering department—that the administrator must know.

The book supplies ready solutions to the many problems that confront the administrator daily, provides administrative methods that will insure managerial and departmental progress, and presents a variety of useful working tools, such as procedures for making engineering changes, and administering the budget.

Described for the engineer in his own language are the complex matters of patent law, financial controls, personnel matters, compensation administration, safeguarding of industrial secrets, and other related subject matter.

The author shows the advantages of separating all administrative duties from the technical personnel. He describes the administrator's role in terms of his responsibilities both to the general management and to the engineering department.

Early Motor-Cars, Second Series The Vintage Years

GEORGE A OLIVER. Stephen Green Press, 120 Main St, Brattleboro, Vt. 14 x 19. 55 pp. $14.95.

This book, spanning the years 1919-1930, is a measure of the impact WWI had on auto design. The horse was finished as a practical means of transportation and the auto became an accepted necessity. The principal result of this change was to impose greater demands on the designer. Engine speeds and power were increased, effective braking became a necessity, improved riding comfort was demanded and the resulting solutions frequently generated further complications.

The cars produced during this period reflect the great number of solutions which can be arrived at when solving any problem. A complicating factor which sprang up as automotive technology improved was the production of cars for specific purposes or tastes. Luxury cars, sports cars, utility cars, economy cars each imposed a different set of parameters and produced a different solution. The result was the production of the greatest variety of auto designs that has ever occurred. The 12 color plates present a sampling of the cars produced and reflect the divergence of taste during this critical period of auto design. —JJK

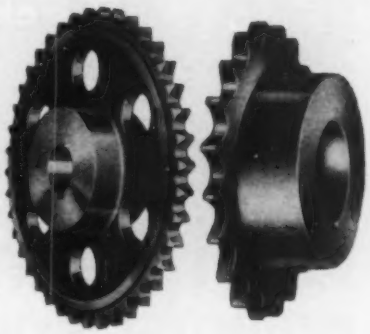
An Introduction to Mechanics, Matter, and Waves

UNO INGARD, WM L KRAUSHAAR. Addison-Wesley Publishing Co Inc, Reading, Mass. 6 x 9, 672 pp. $10.75

This textbook first investigates two-body collisions and thus begins the course with inertial mass, momentum and its conservation, and center-of-mass motion—all fundamental and interesting aspects of the physics of motion which require no calculus. The

continued, page 195

A Morse answer



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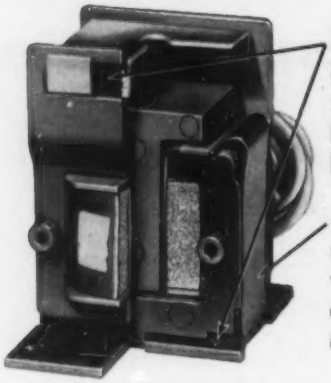

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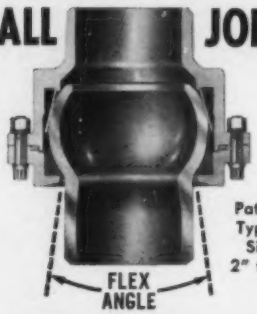

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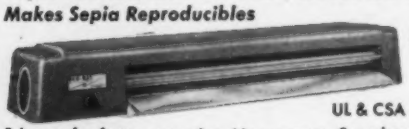

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concept of force then emerges as the rate of momentum transfer from one body to another during an interaction. The conservation laws—conservation of mass, momentum, energy, and angular momentum—have been given more than the usual emphasis. In fact, collision experiments and momentum conservation not only serve as the starting point but as a central theme through much of the book.

Other chapters cover forces and motion, angular momentum, moving coordinate systems and inertial forces, the temperature concept and thermal interactions, kinetic theory, thermodynamics, and properties of matter.

Other Books of Interest

High Temperature Research

SB-453. Office of Technical Services, US Dept of Commerce, Washington 25, DC. 8 *x* 10½, 36 *pp.* 10¢

A bibliography including material on ceramics, gases, plastics, electrical and electronic equipment from period 1949-60.

Effect of State of Stress on the Failure of Metals at Various Temperatures

PB 171366. D R Jenkins, H E Gascoigne, L W Wolf, S K Clark. Office of Technical Services, US Dept of Commerce, Washington 25, DC. 8½ *x* 11, 27 *pp.* $1.

An attempt to combine various theories of fracture into two theories: one for ductile failures and one for brittle failures.

An Evaluation of Time-dependent, Materials Information for Purposes of Pressure Vessel Design and Analysis

NYO-9376. Office of Technical Services, US Dept of Commerce, Washington 25, DC. 8½ *x* 11, 233 *pp.* $3.

Fuel Cells and Related Research

SB-447. Office of Technical Services, US Dept of Commerce, Washington 25, DC. 8½ *x* 10, 7 *pp.* 10¢

A bibliography including material from period 1945-60.

Sequential Decoding

J M Wozencraft, B Reiffen. John Wiley & Sons, Inc, 440 Park Ave South, NY 16. 6 *x* 9¼, 74 *pp.* $3.75

Principles of Manufacturing Materials and Processes

J S Campbell Jr. McGraw-Hill Book Co Inc, 330 W 42nd St, NY 36. 6 *x* 9¼, 674 *pp.* $9.75

Theory of Metal Cutting

P H Black. McGraw-Hill Book Co, Inc, 330 W 42nd St, NY 36. 6 *x* 9¼, 204 *pp.* $7.50

Engineers and What They Do

Harold Coy. Franklin Watts Inc, 575 Lexington Ave, NY 22. 5½ *x* 8½, 186 *pp.* $3.95

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continued, page 196

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See our guide-book on RULON, Bulletin #9572, in Sweet's Product Design File or send details for recommendations. DIXON CORPORATION, 103 BURNSIDE ST., BRISTOL, R. I.

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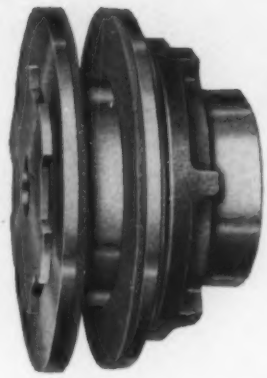

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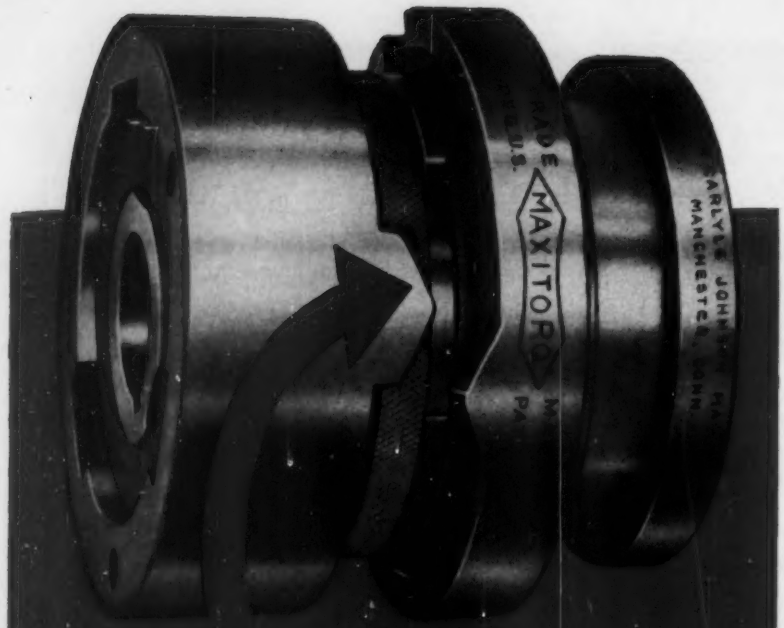

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Concepts of Space

Max Jammer, Harper & Brothers, 49 E 33*rd St, NY* 16. 5¼ *x* 8, 208 *pp.* $1.40

Paperback edition of a book originally published in 1954, discusses history of man's concepts and theories about space.

High-temperature Metallography

M G Lozinskii. Pergamon Press Inc, 122 East 55*th St, NY* 22. 7 *x* 10¼, 484 *pp.* $17.50

Economical Atlas of the Soviet Union

George Kish. University of Michigan Press, Ann Arbor, Michigan. 10½ *x* 10½, 96 *pp.* $10

ABSTRACTS

Corrosion of Stainless Steel

Sensitization, carburization, sources of hydrochloric acid and dirt are the main causes of failure. The authors explain why and point out the preventive measures that should be taken.

"Why Does Stainless Steel Corrode?" by Sinclaire and Phillips, Douglas Aircraft Co Inc. Metal Progress, Sept 1961, *American Society for Metals, Novelty, Ohio.*

Measurement of Temperature in a Duct

When fluid flows in a pipe or duct, there is a radial velocity gradient. If the wall temperature is not the same as the fluid temperature, there also will be a radial temperature gradient. The mean or average temperature is not the temperature at the center and the center is not the best place to locate a temperature sensor. This article tells how to calculate the best location for a sensor in a long straight pipe.

"Measurement of Mean Temperature in a Duct," by Deleo, Werner and Hagen, Rosemount Engineering Co. Instruments & Control Systems, Sept 1961, 845 *Ridge Ave, Pittsburgh* 12.

Free Engineering?

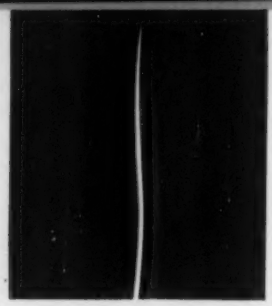
Engineering services rendered free of charge by suppliers are discussed by a manufacturer and an engineering consultant.

"Free Engineering," by F. C. Heller, Babcock & Wilcox Co. Mechanical Engineering, Sept 1961, *ASME,* 345 *East 47th Street, NYC.*

Compound Beams

A thorough investigation was carried out using the simplest method of solution in each case, determinants only being resorted to in the general case mentioned. In the first instance, a compound beam is regarded as a uniform beam with concentrated loads

continued, page 200



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To put it differently, no other material combines so many outstanding properties as the Stainless Steels. Stainless Steels have high tensile strength. All are hardened and made even stronger by cold working. As a family they offer superb resistance to the corrosive effects of an enormous variety of reagents. They have unusual resistance to high temperature oxidation, and are distinguished by relatively low heat conductivity. And on top of their remarkable physical properties, Stainless Steel's lustrous appearance and sales appeal scarcely need mention.

By reflecting the color of its surroundings, Stainless Steel contributes to harmonious design.

The history of Stainless Steel's use is marked by designers who turned a healthy profit with a quality material but mainly with sound ideas. They're the men who used Stainless for its strength and sales appeal in toaster covers, for its appearance and machinability in wrist watches, its structural properties and cleanability in truck trailer parts. Stainless Steel cuts weight and adds years to the life of architectural panels; its corrosion resistance and smooth, pit-free surface have made it the standard of the dairy industry. There are literally thousands of applications of Stainless Steel in which designers have utilized one, two or more of the remarkable properties of Stainless Steel.

Successful designers don't substitute Stainless Steel sections for sections of other materials. They design to Stainless' unique properties.

Good design doesn't stop with function and sales appeal. It must also be capable of economical manufacture. As a comprehensive guide, send for the free book described at the right.

Good design is honest design, whether it uses Stainless Steel or other materials. Yet the fact remains that there is no other commercial material suited to such a varied range of applications as Stainless Steel. The applications shown on these pages are just a few of the hundreds of uses to which Stainless is put every day. To learn more about Stainless Steel and its design properties, call our nearest sales office or write United States Steel, 525 William Penn Place, Pittsburgh 30, Pa.

Stainless Steels represent but a few of the thousands of grades of steel in existence today. United States Steel makes a complete line of Stainless Steels as well as alloy, high strength and carbon steels. Bring your design problems to us.

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Order Stainless Steel from your nearest Steel Service Center.

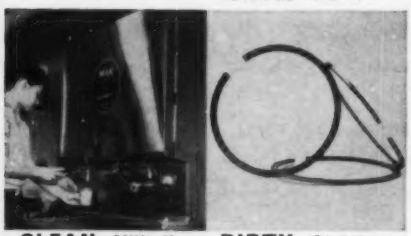
No material comes close to Stainless Steel's versatility. By way of illustration, here are a few "opposites" that prove our point.

HOT. Temperatures in a jet afterburner reach 1400°F.

COLD. Stainless heat exchanger operates at temperatures as low as —443°F.

WET. Combination of moisture and coal would corrode nearly anything but Stainless.

DRY. Rotary dryer is used to dry pharmaceutical ingredients.



CLEAN. Milk dispensers of Stainless Steel prevent contamination.

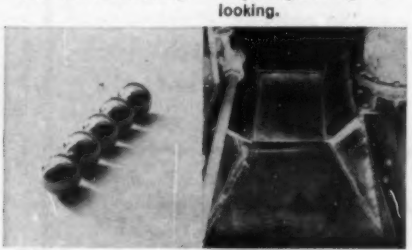
DIRTY. Stainless piston rings resist high temperature corrosion.

INSIDE. Chemical tanker needs simple wash-out for cleaning.

OUTSIDE. Stainless automobile trim stays bright and good-looking.

LIGHT. Stainless Steel jewelry has a light, graceful appearance.

HEAVY. Strength and hardness of Stainless combine to make safe doors safe.

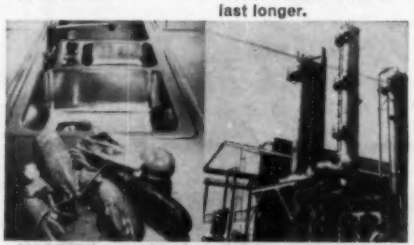


ROLL. Stainless ball bearings take a lot of punishment.

SLIDE. Abrasion resistance of Stainless Steel makes chutes last longer.

FORM. Stainless Steel wrist watch keeps time and beauty.

FUNCTION. Stainless Steel muffler defies heat with silence.



WATER. Stainless sinks stay bright and beautiful.

FIRE. Stainless Steel shingles inside cat crackers are red hot.

Stainless Steel's properties require close control over processing and in some cases, special fabricating techniques. Its cold working and joining characteristics are of special interest to the designer and will often influence final design. For complete coverage of the subject send for your free copy of our newly revised manual:

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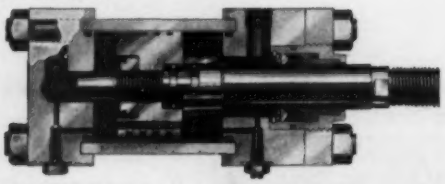

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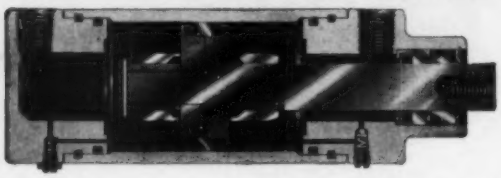

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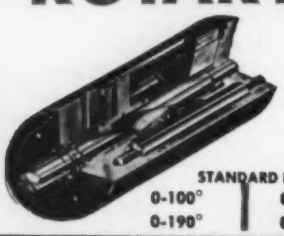

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"Vibration of Compound Beams," by W. H. Sheppard, Mechanical World, June 1961. 31 *King Street W, Manchester* 3, *England.*

Molding vs casting for epoxies

Discusses electrical applications best suited to encapsulation by casting, compares casting and molding formulations and lists properties. Capital requirements and tooling costs are also considered and possible savings are described.

"Molding vs Casting for Epoxy Encapsulation," by Gerard B. Rugg, Wabash Magnetics Inc. Modern Plastics, Sept 1961, 770 *Lexington Ave, NYC.*

CATALOGS AND BULLETINS

To obtain copies of literature described below, circle corresponding number on postcard inside back cover. For those catalogs and bulletins available only when requested on company letterhead, see page 217.

CYLINDRICAL ACCUMULATORS—Catalog, 80 pp. Both single and double-shell units ranging in oil volume from 7.07 cu. in. to 43.7 gal. max, with max working pressures of from 2000 to 5000 psi, are displayed in cutaway views. Dimensions, specifications and volume-pressure charts are given. Superior Hydraulics Div, Superior Pipe Specialties Co, PO Box 3844, Cleveland 10.

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BALL BEARINGS—Catalog, 48 pp. Covers miniature and instrument ball bearings, tabulating dimensions and discussing such characteristics as starting torque limits, axial deflection, radial play, etc. Applications are reviewed. New Departure Div, General Motors Corp, Bristol, Conn.

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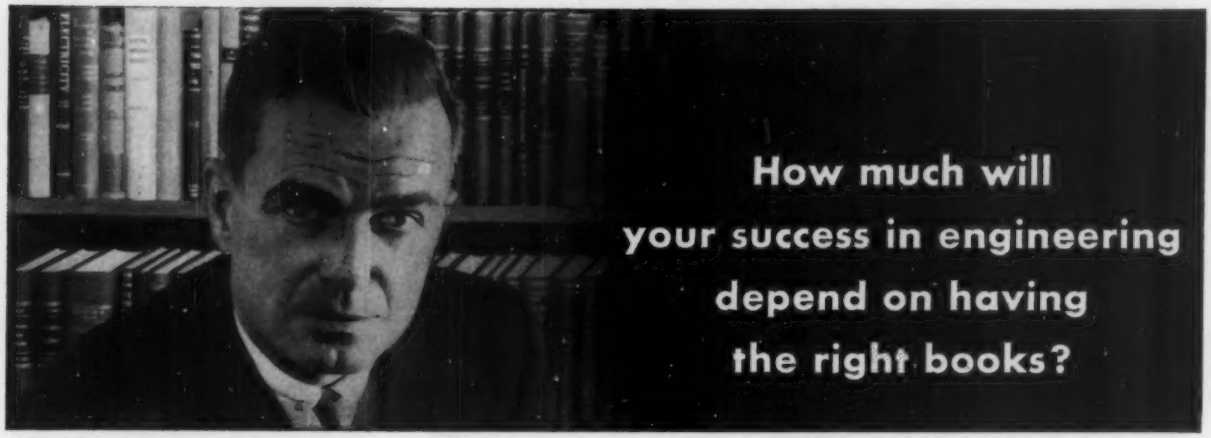
MECHANICAL DIFFERENTIALS—Brochure 8101, approx 84 pp. Contains 27 "A"-size drawings of stock and pre-engineered differentials

continued, page 203



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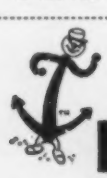

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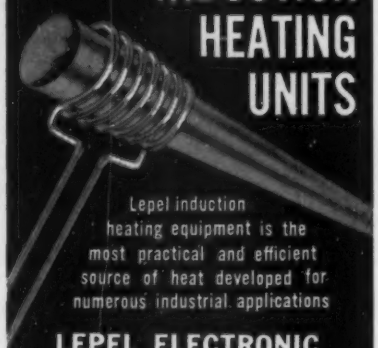

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that can be traced or reproduced by ozalid. Also outlines design criteria and test data on actual stock differentials. Dynamic Gear Co Inc, 175 Dixon Ave, Amityville, LI, NY.

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FASTENERS—Brochure 359, 32 pp. Supplies dimensions, other specifications, mechanical drawings, etc. of fasteners and retainers in popular sizes. Discussion is devoted to multiple-function fasteners. Tinnerman Products Inc, Dept 14, PO Box 6688, Cleveland 1.

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BALL VALVES—Catalog 1200-A, 32 pp. Valves described and illustrated range in size from ¼ through 12 in., with screwed, socket weld and flanged end models for temperatures from −150 to 1000 F, pressures to 1000 psig and vacuum to 10^{6} mm Hg. Included are dimension data, pressure-temperature rating curves, typical C_v values, material specifications and 4-page list of suitable body materials and various seat materials for wide range of services. Hills-McCanna Co, 400 Maple Ave, Carpentersville, Ill.

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PUMPS AND CONTROLS—Bulletin 47740, 20 pp. Covers variable displacement, electrohydraulic, servo-controlled units, carrying cutaway views, pump stroke times, dimensions and specifications and control system diagrams. Oilgear Co, 1560 W Pierce St, Milwaukee 4.

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BALL RADIAL BEARINGS—Bulletin S-141, 4 pp. Spells out capacities, shaft and housing sizes, bearing internal clearances, shoulder diameters, material specifications and mounting data on 90 sizes of extremely thin section bearings. Kaydon Engineering Corp, Muskegon, Mich.

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HOLLOW ALUMINUM STOCK—Booklet, 12 pp. Explains material cost savings and other benefits obtained from using hollow aluminum screw

continued on page 204

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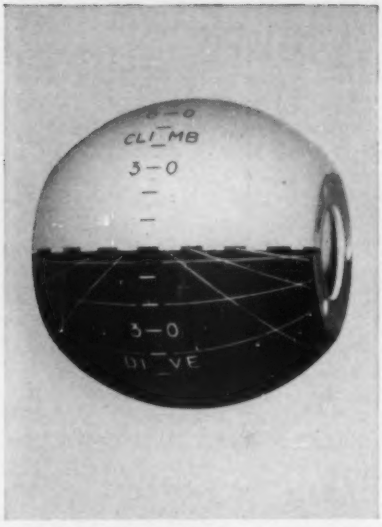

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DESIGN LITERATURE

machine stock and mechanical tube instead of solid stock. Tabular data outlines machinability and corrosion resistance ratings, mechanical properties and specifications of various alloys and range of sizes and alloys offered. Aluminum Co of America, 731 Alcoa Bldg, Pittsburgh 19.
Circle 358 on Reader Service Card

LOW HP FANS—Bulletin ASQ-102, 12 pp. Supplies design advantages, diagrams on mechanical efficiency, selection tables for each of seven sizes (8¾ to 18¼) and dimension data. Chicago Blower Corp, 9800 Pacific Ave, Franklin Park, Ill.
Circle 359 on Reader Service Card

DIFFERENTIALS—Two brochures, 4 pp each. One outlines and diagrams principles of operation, along with a speed, torque and power analysis of bevel gear differential. Second publication reviews various sizes available in basic gearing and transmissions. Rating and dimension tables are included. Industrial Products Branch, Stratos Div, Fairchild Stratos Corp, Rt 109, West Babylon, NY.
Circle 360 on Reader Service Card

TFE O-RINGS—Catalog P-1A, 4 pp. Lists over 250 sizes of the self-lubricating tetra-fluoro-ethylene fluoro carbon resin O-rings, giving nominal dimensions of ID, OD and width, along with actual decimal dimensions and tolerances for ID and width. Prices for quantities up to 20,000 are included. Chicago Gasket Co, 1271 W North Ave, Chicago 22.
Circle 361 on Reader Service Card

SWITCH, THERMOSTAT PACKAGES—Bulletins PRSW-10B and PRET 26, 8 pp each. Former covers packaged precision switches, including metal-to-metal and glass-to-metal, hermetically sealed types, while latter covers hermetically sealed, snap-acting and rod and tube type thermostats. Both carry performance data and dimension drawings. Metals & Controls Inc, Div of Texas Instruments Inc, 34 Forest St, Attleboro, Mass.
Circle 362 on Reader Service Card

SPEED REDUCER—Bulletin 602A, 4 pp. Deals with small shaft-mounted unit designed for shafts 1½ in. or less and for power requirements up to 1 hp at 90 rpm. Included are engineering drawings, dimensions, weights, prices, table of recommended V-belt drives and table of hp ratings for various classes of service. Dodge Mfg Corp, Mishawaka, Ind.
Circle 363 on Reader Service Card

IMPULSE TRANSMITTERS—Folder, 4 pp. Specifications and dimension drawings are carried on rotary motion unidirectional, rotary motion bi-directional, lever actuation, fixed time ratio and adjustable time ratio types. Landis & Gyr, 45 W 45th St, New York 36.
Circle 364 on Reader Service Card

DIGITAL ROTOPULSERS—Bulletin 200-A, 4 pp. Describes operation and presents specification and application data on the transducers that convert motion into pulses. Dimension drawings are included. Louis Allis Co, Dept P, 427 E Stewart St, Milwaukee 1.
Circle 365 on Reader Service Card

STRUCTURAL DAMPING—Bulletin 719, 8 pp. Carries performance data on damped laminate forms and shapes and printed circuit boards. Explains advantages of standard and custom structures in protecting sensitive equipment exposed to random, high intensity vibration, shock and

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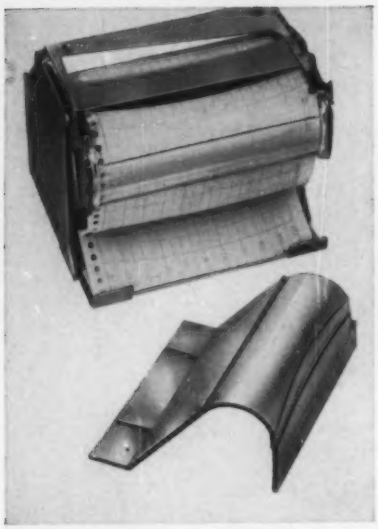
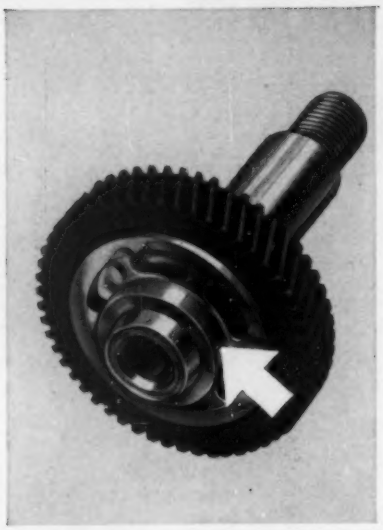


TRANSPARENCY of LEXAN resin is important in chart guide for recorder. LEXAN resin is the only transparent plastic able to withstand heat generated by internal lights. It is distortion-free at temperatures up to 270°F and self-extinguishing. Its extremely high impact strength eliminates cracking of guides. (The Foxboro Co.)



TOUGHNESS. Press-fitted into metal gear used in an electric drill, bushing of LEXAN polycarbonate resin provides safety from electric shock . . . helps eliminate need for additional grounding. Strength and creep resistance of LEXAN resin enables bushing to withstand torque and load requirements of drill. (Millers Falls Co.)

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noise. Also delves into basic considerations in design and selection of protection systems. Lord Mfg Co, Erie, Penna.

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REINFORCED PLASTIC—Bulletin 8.5, 2 pp. General and thermal properties of high-temperature, asbestos-base reinforced plastic are outlined, while sizes are given for various forms, including laminated sheet, molded rod, molded tube, rolled tube, molded shapes and molding forms. Taylor Fibre Co, Norristown, Penna.

Circle 367 on Reader Service Card

DISK BRAKES—Bulletin NPP 3-61-B, 4 pp. Contains engineering drawings and torque and current specifications of series of self-adjusting brakes. Stearns Electric Corp, 120 N Broadway, Milwaukee 2.

Circle 368 on Reader Service Card

INDUSTRIAL GREASE — Booklet, 32 pp. Discusses basic principles, properties, types and rules for choice and application of lubricating grease, including effect of additives on properties. Bardahl Mfg Corp, 1400 N W 52nd St, Seattle 7.

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POLYCARBONATE RESIN—Brochure CDC-397, 6 pp. Electrical and physical properties of Lexan polycarbonate resin for electrical and electronic components are detailed in tables and curves. Typical applications are described and illustrated. General Electric Co, Chemical Materials Dept, Pittsfield, Mass.

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RELAYS—Short form catalog, 6 pp. Provides specifications, operating data and application information on general purpose, plate circuit, industrial control, telephone, printed circuit, sensitive, digital counter, antenna, power and plug-in relays. Hillburn Electronics Corp, 55 Greenpoint Ave, Brooklyn 22, NY.

Circle 371 on Reader Service Card

STAINLESS STEEL CYLINDERS—Bulletin 1260, 10 pp. Describes design features and supplies dimensions and prices of ¾ to 1½-in. bore stainless steel body units. Bimba Mfg Co, 101 Main St, Monee, Ill.

Circle 372 on Reader Service Card

ELECTRIC VIBRATORS—Bulletin 81461, 12 pp. Specifications and dimensions of 14 standard "pulsating-magnet" models, as well as three pneumatic and hydraulic units are presented. Application of vibrators to hoppers and chutes is discussed and illustrated. Syntron Co, 240 Lexington Ave, Homer City, Penna.

Circle 373 on Reader Service Card

HYDRAULIC RUBBER HOSE—Catalog, 16 pp. Furnishes design and performance data on single wire reinforced design for medium pressure service and a high pressure design with two layers of wire braid reinforcement. Titeflex Inc, 603 Hendee St, Springfield 4, Mass.

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WIRE CLOTH—Catalog, 16 pp. Covers plains, twill, dutch, micronic and special weaves, presenting specifications and characteristics of coarse to extra-fine meshes. Uses for various types are traced. Unique Wire Weaving Co Inc, 762 Ramsey Ave, Hillside, NJ.

Circle 375 on Reader Service Card

ELECTRICAL EQUIPMENT—Bulletin A-17, 4 pp. Catalogs automatic transfer switches magnetic contactors, special electromagnetic controls and

Continued, page 209

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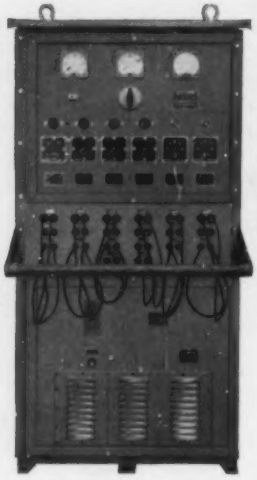

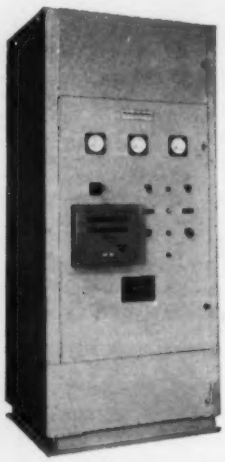

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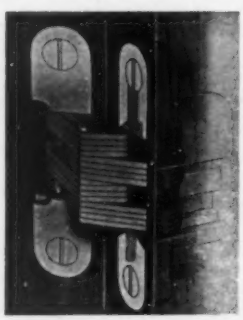

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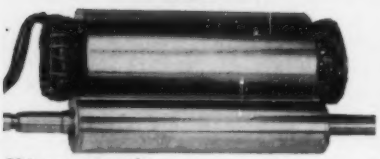

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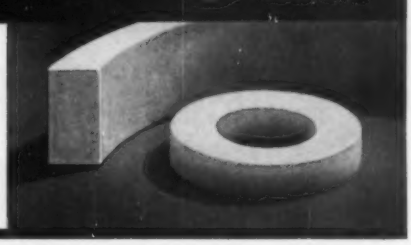

Parco-Matic Economolding permits huge quantity O-Ring production at vastly reduced costs. Parco's automated Economolding method, utilizing the square cross section, permits rapid molding economies to be achieved which formerly required expensive machining. Most parts incorporating round cross-sectioned rings which require expensive machining can be readily modified to utilize this unique Parco breakthrough.

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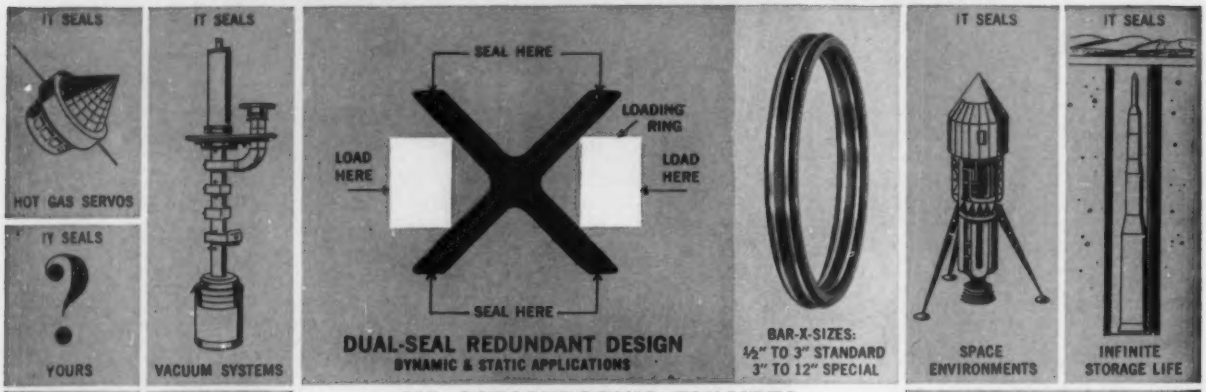

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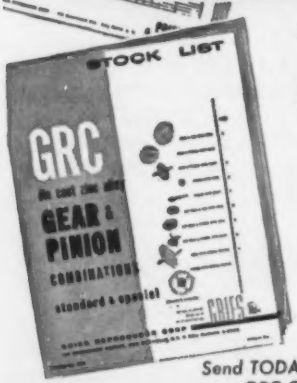

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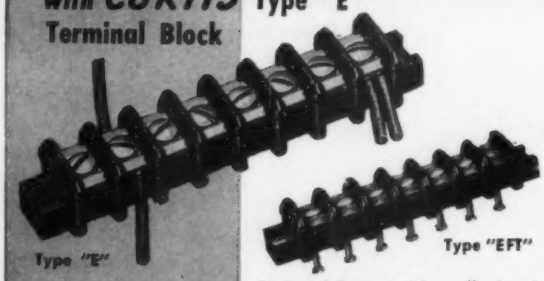

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CONTROL VALVES — Catalog DCV-1, 8 pp. Contains data on ¼- to 6-in. units, including available metals, pressure and temperature ratings, features, capacity charts, names of parts, dimensions, flow chart, diagrams of various hookups, sample specifications, etc. OPW-Jordan, 6013 Wiehe Rd, Cincinnati 37.

Circle 377 on Reader Service Card

PUMPS AND MOTORS — Bulletin 100-P19, 4 pp. Capabilities of oil hydraulic fluid power 2500-psi units are presented in photos, line drawings and performance data charts. Also covered are flange mountings, port end covers, gear housings, drive shafts, and gear widths available. Commercial Shearing & Stamping Co, 1775 Logan Ave, Youngstown 1, Ohio.

Circle 378 on Reader Service Card

ALUMINUM - IMPREGNATED STEELS—Data sheets, 4 pp. Characteristics, properties, forms and shapes, special features, applications, installation, etc. are noted. Corrosion Tubing Div, M L Sheldon & Co, 350 Lexington Ave, New York 16.

Circle 379 on Reader Service Card

TENSILE TESTERS—Bulletin 750/P, 4 pp. Discusses construction and operation of two models—one designed for testing breaking strength of electrical leads and connections and other for testing many small parts or material samples as well. Available capacity ranges and accuracy of each is outlined in tabular form. Hunter Spring Co, Div American Machine & Metals Inc, Lansdale, Penna.

Circle 380 on Reader Service Card

HYDRAULIC POWER PACKAGES —Bulletin 61-82, 4 pp. Offers rundown on design options, photos of typical models and chart listing recommended motor sizes for various pressures and flows. Vickers Inc, Div of Sperry Rand Corp, Detroit 32.

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MULTIPLE CONNECTORS—Folder, 6 pp. Describes three separate lines, providing specifications for each. Included are contact sizes and materials, wire crimp and insulation support, wire and insulation size ranges, receptacles and housings. Also de-

continued, page 213

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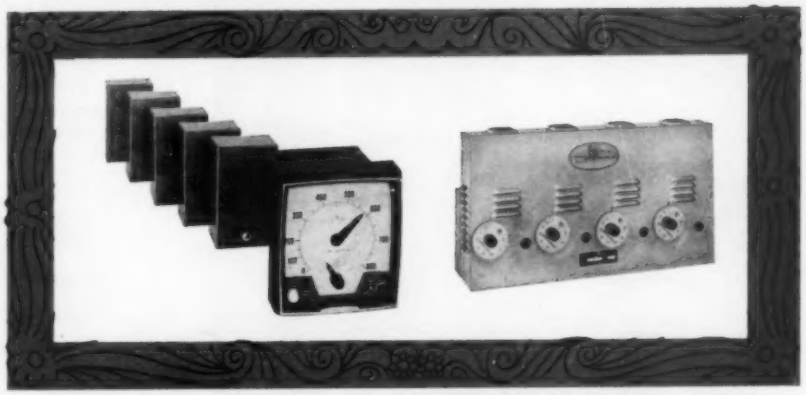

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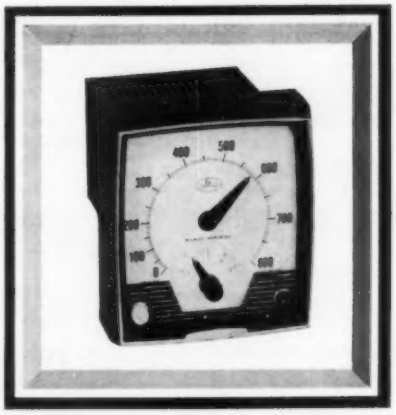

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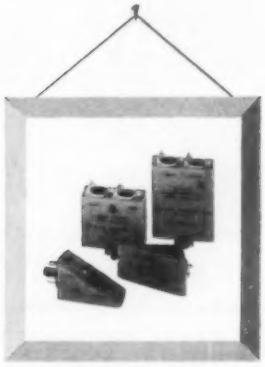

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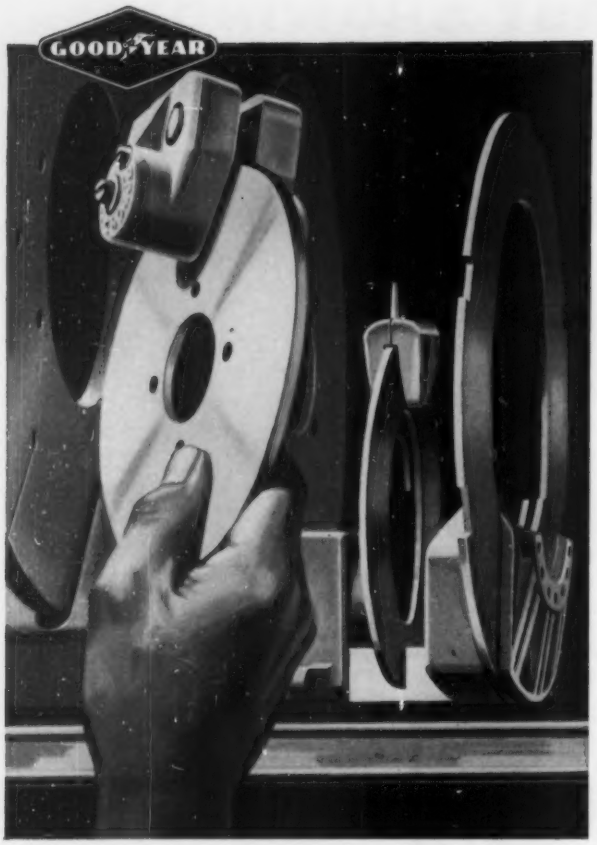

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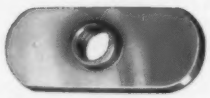

ND NUT—for spotwelding. Used where large nut is needed for bridging two sheets or for extra strength.
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Stoner's SMR has broken through the thermal sealant barrier that has faced the missile and rocket industry for many years.

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*SMR is a special Silicone Modified Rubber produced by Stoner Rubber Company, Inc.

Photo of Rocket Chamber courtesy of Aerojet-General Corporation

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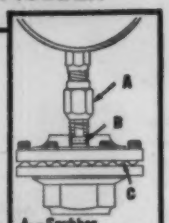

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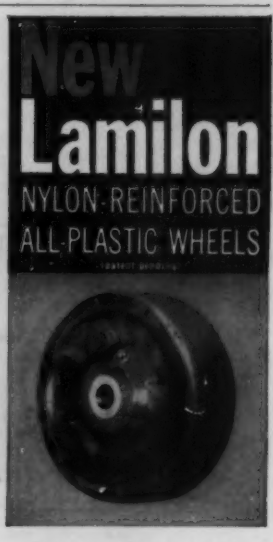

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scribed are compression-crimp technique and tooling, both hand and automatic, for attaching terminals to circuit leads and for stripping wire preparatory to crimping. AMP Inc, Eisenhower Blvd, Harrisburg, Penna.
Circle 382 on Reader Service Card

VALVES—Data sheet AD-502, 2 pp. Contains drawings and specifications of two series of relief and check valves, showing leakage rate, cracking pressure, flow rate and pressure drop. Dimension drawings are included. IMC Magnetics Corp, Marketing Div, 6058 Walker Ave, Maywood, Calif.
Circle 383 on Reader Service Card

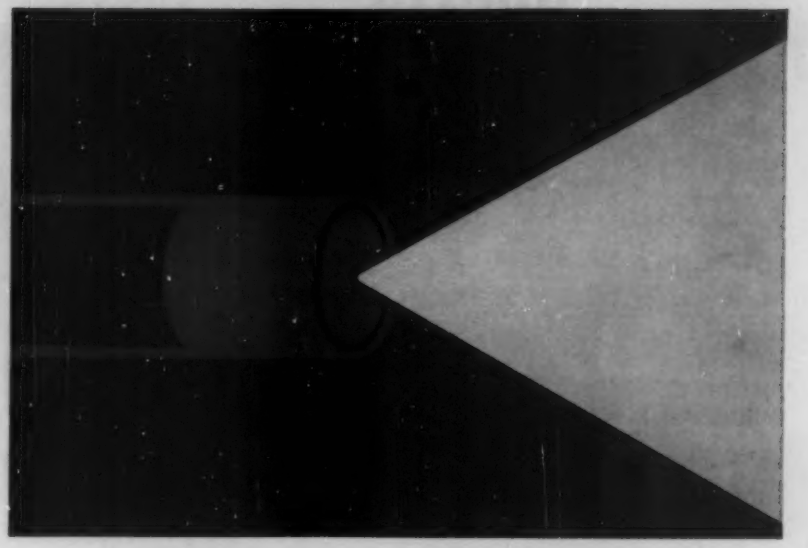
EXPLOSION-PROOF MOTORS—Bulletin 1000, CD, 2 pp. Describes electrical and mechanical design features of integral-hp, ac units and lists principal dimensions for various NEMA frame sizes. Leland Ohio Electric Co, 1501 Webster St, Dayton 1, Ohio.
Circle 384 on Reader Service Card

GLASS-TO-METAL SEALS—Bulletin 10, 4 pp. Spells out applications, environmental conditions and specifications of seals and provides diagrams of contact configurations, multiple headers and standard connectors. Networks Electronic Corp, 9750 De Soto Ave, Chatsworth, Calif.
Circle 385 on Reader Service Card

SMALL DIAMETER TUBING—Bulletin 13, 20 pp. Sets forth sizes, specifications, finishes, tolerances, chemistry and suitable applications of tubing up to 1 in. OD. Also covers special metals and alloys, tracing their general characteristics. J Bishop & Co, Platinum Works, Malvern, Penna.
Circle 386 on Reader Service Card

BUILD-IN INSTRUMENTS—Catalog 61-124, 28 pp. Illustrates, describes design features and lists specifications of miniaturized panel-mounting dc and ac VTVM's and TRVM's. Discusses fundamentals of range selection, scale plate selection and principles and applications of phase-sensitive voltmeter. Trio Laboratories Inc, Plainview, LI, NY.
Circle 387 on Reader Service Card

HIGH ALLOY CASTINGS—Catalog G-261, 20 pp. Lists Alloy Casting Institute nomenclature, metallurgical properties and broad uses of some 55 different alloys, with emphasis on recently developed alloy for castings to be used in 2100-2200 F range. Dis-
continued, page 217



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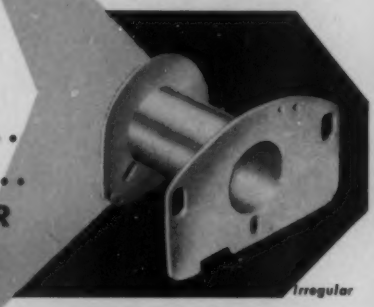
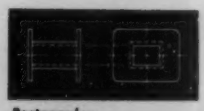
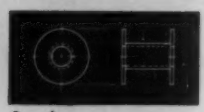


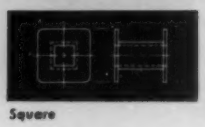
Irregular



Rectangular



Round



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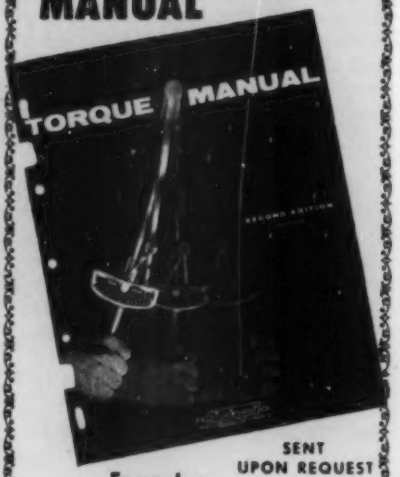

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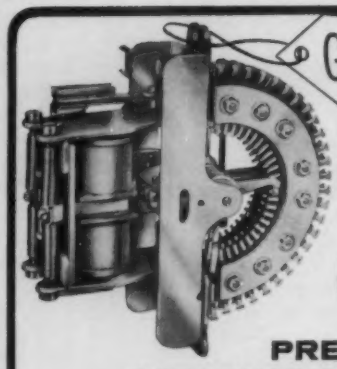

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for circuits which require a switch that steps positively, in either direction, around a bank of 25 contacts. **FEATURING:**

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- bridging or non-bridging wipers
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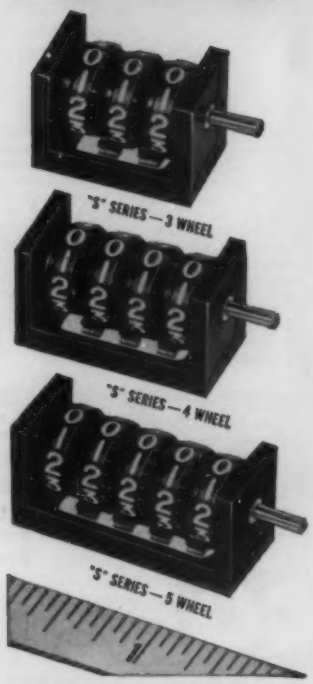

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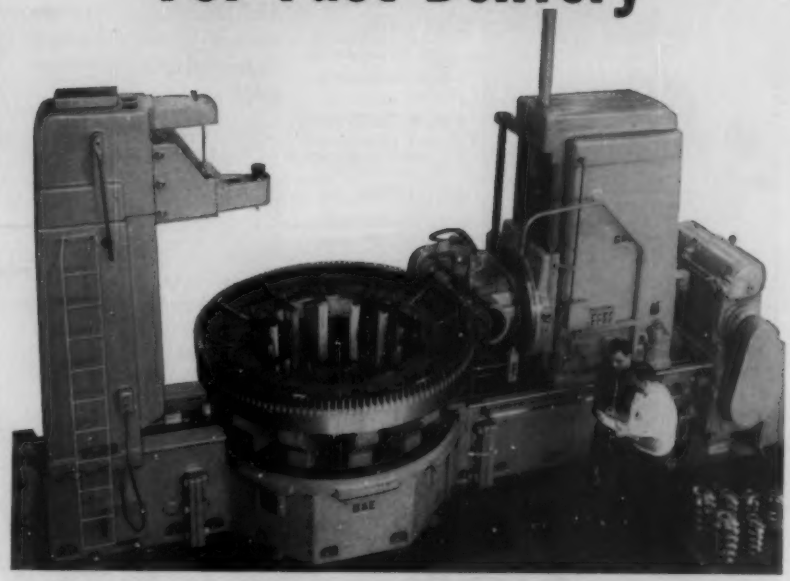

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Up to 80″ outside diameter at 1 DP
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Face widths up to 42″, depending on helix angle

Send your specifications, or let our technical staff make recommendations. H & S specializes in fast production of quality industrial Gearing and Speed Reducers to meet your custom requirements.

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9000-B (1-10 H. P.)
TORQUE RATING: 1400 pound inches output, 350 pound inches input
HORSEPOWER RATING: ¼ H.P., 900 r.p.m. input; 1 H.P., 1800 r.p.m. input
GEAR RATIOS: 1:1—2:1—3.14:1—4:1 Special ratios at extra cost. Maximum Reduction 5.07:1

8100-B (10-20 H. P.)
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HORSEPOWER RATING: 10 H.P., 900 r.p.m. input; 20 H.P., 1800 r.p.m. input
GEAR RATIOS: 1:1—2:1—3:1—4:1 Special ratios at extra cost. Maximum Reduction 6.00:1

14800 (left)—Four special speed changes up to limit of case 10:1
14900 (left)—Four speed changes in geometric progression at 1.71 (total reduction of 5.83)
TORQUE RATING: 1400 pound inches input 7500 pound inches output
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. . . for industrial and agricultural machinery, automotive trucks, tractors, refuelers, industrial shovels, cranes, shop and lift trucks, concrete mixers, road builders, diamond drills, machine tools . . .

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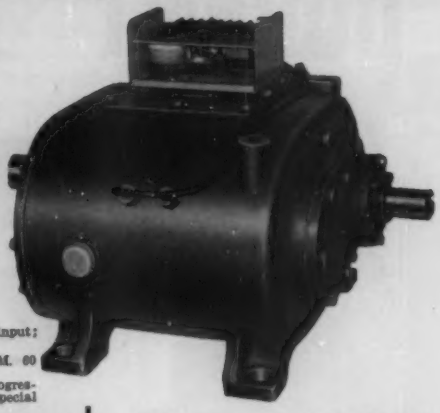
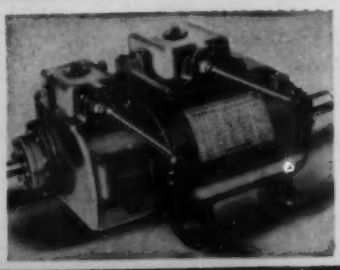
9300 (30-60 H. P.) below
TORQUE RATING: 2100 lb. in. input; 12,000 lb. in. output.
H.P. RATING: 30 H.P. at 900 R.P.M. 60 H.P. at 1800 R.P.M.
Eight Speed Changes in geometric progression of 1.29 (total reduction 6:1) Special ratios at extra cost.





Transmissions with Electro-Magnetic Clutches provide speed changes and reversing under power, without interrupting power source . . . so equipped are available with two to eight speeds, capacities from 52 to 750 foot pounds and a wide ratio selection (up to 10:1). Manual or automatic controlling of speed changes accomplished with electric switches, tape, cam or other remote control means available. Especially adaptable to automatic machinery where transmission is not accessible to the operator. Model 14800-EC (above) Control Box has cover Plate removed.

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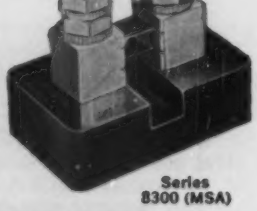

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cussed are static, centrifugal and shell-molded castings. Duraloy Co, Scottsdale, Penna.

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LIGHT METALS—Brochure, 44 pp. Design data on characteristics and properties of light metals, including magnesium, aluminum and titanium, is presented in tabular and graphic form. Comparative values for various metals are listed. Brooks & Perkins Inc, 1950 W Fort St, Detroit 16.

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LETTERHEAD REQUESTS ONLY

Manufacturers who published following literature asked that requests for copies be made on company letterheads.

PUMPS—Catalog, 1008 pp. Covers centrifugal, axial and mixed flow pumps, with data arranged to permit ready "engineering" of pumping units and selection of materials of construction. Range charts, performance curves, dimensions, prices, etc are furnished, along with reference data relating to pumps and hydraulic design. Allis-Chalmers, Box 512, Milwaukee 1.

PRECISION BALLS—Catalog, 16 pp. Reviews general applications, specific material characteristics, mechanical properties, resistance factors, machinability, hardness, size, weight, etc. Also contains AFBMA definitions, cross reference charts for previous and present AFBMA Standards and master table of ball grades and tolerances. John T. Kelley, Hartford Steel Ball Co, 12 Jefferson Ave, West Hartford, Conn.

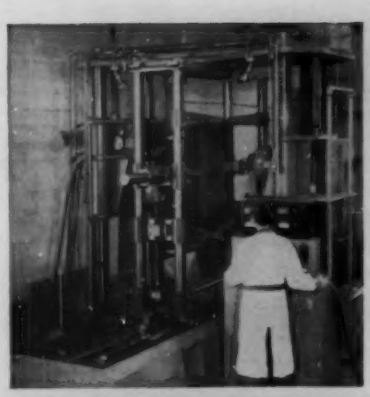
LABORATORY FACILITIES—1961 directory, 114 pp. Serves as guide to leading independent testing, research and inspection laboratories in the nation. Executive Secretary, American Council of Independent Laboratories Inc, 4302 East-West Hwy, Washington 14.

Answers to problems on page 164.

1. $\frac{1}{y} = \ln x + 1 + cx$

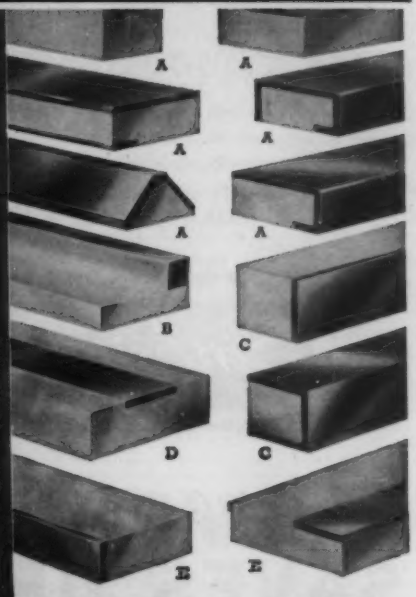
2. $y = \frac{x(\ln x)^4}{24}$

3. $y^3 = \frac{3a^2}{2x}$



NEW DRILLING MACHINE PRODUCES MULTIPLE HOLE PATTERNS WITH ABSOLUTE ACCURACY. Built by Walter P. Hill, Inc., Detroit, Mich., this opposed-spindle drilling machine has a flexible automatic system for positioning heads and table for producing hole patterns. To achieve the high degree of accuracy necessary, all components must continually operate on close tolerance. The exposed ways get brutal treatment (falling steel chips, operator walking and standing on them). Hardened ways were selected to run against processed aluminum bronze wear plates, all made by The Ohio Knife Co., Cincinnati, Ohio. These ways are so hard (Rockwell 66 C) as to practically eliminate galling or scoring.

A—Hardened Ways and Slides
B—Composite Die Sections
C—Heel Block
D—Center Clad
E—Flange Slide



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hardened ways and wear plates

NEW SHAPES—12 cross sections.

NEW USES—for dies, die sections, flange sections, ways, gibs, rails.

88 SIZES—every practical width and height up to 168" length.

65-66 ROCKWELL—to full depth of tool steel along entire length.

READY TO USE—delivered with cutting, forming, wearing surface machined, hardened and ground. Soft steel backing quickly drilled.

LOWER PRICES—production in large quantities enables us to price them below yours or other makes.

DELIVERY FROM STOCK — to five weeks on all sections including clad aluminum bronze.

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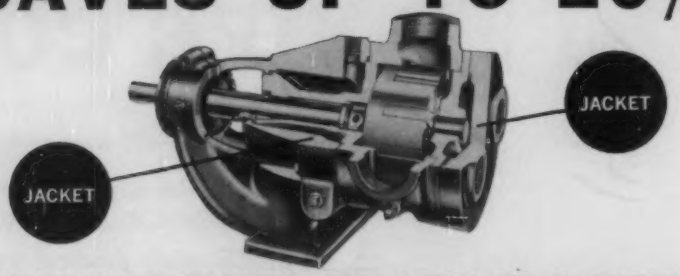

VIKING'S COMPLETE NEW LINE OF JACKETED STAINLESS STEEL* PUMPS

*Also other alloys—nickel, Monel, steel, Ni-Resist, etc.

Now you save money on *new* type stainless steel Viking Pumps and still get that same rugged, heavy-duty service. The new, improved design makes it possible. All parts coming in contact with the material handled are stainless steel or other specified alloy—other parts are cast iron. Its unique design incorporates a jacket chamber around the back of the pump, around the mechanical seal or packing chambers and over the head of the pump. This chamber permits cooling or heating of the liquid being pumped.

Mounting dimensions remain the same as Viking's previous compact line of alloy heavy-duty pumps, and without increased size for jacketing.

Six sizes from 10 to 110 G.P.M. are available. Pumps operate at full speed handling light liquids—at reduced speeds for heavy, viscous liquids. Pumps suitable for pressures up to 50 P.S.I. handling non-lubricating liquids—100 P.S.I. on lubricating liquids. Completely self priming with positive discharge.

50 YEARS

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VIKING PUMP COMPANY

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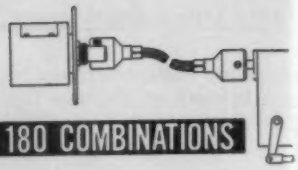

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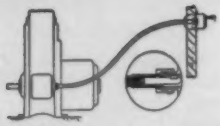

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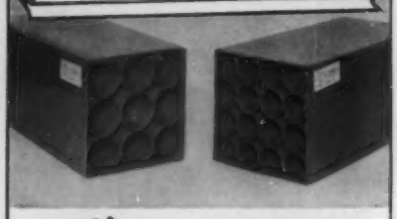

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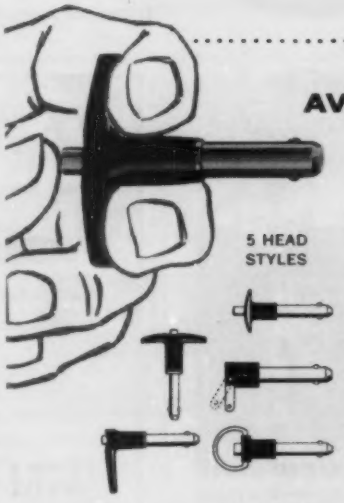

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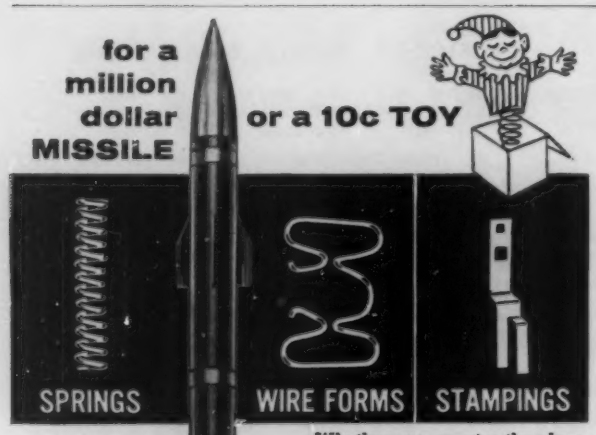

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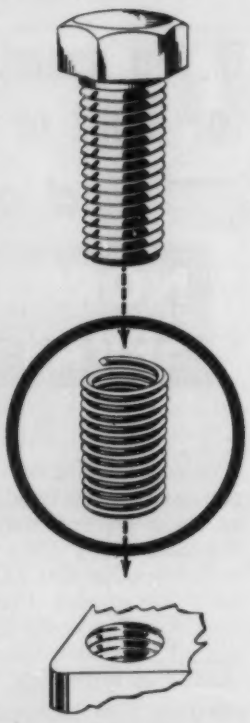

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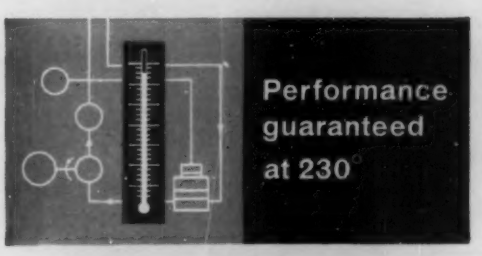

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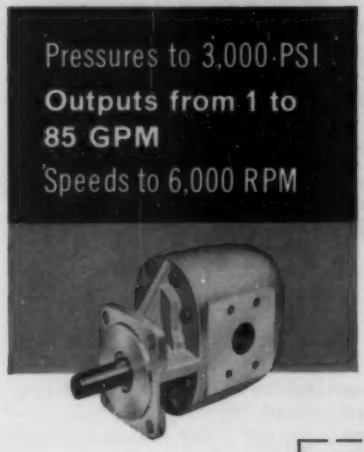

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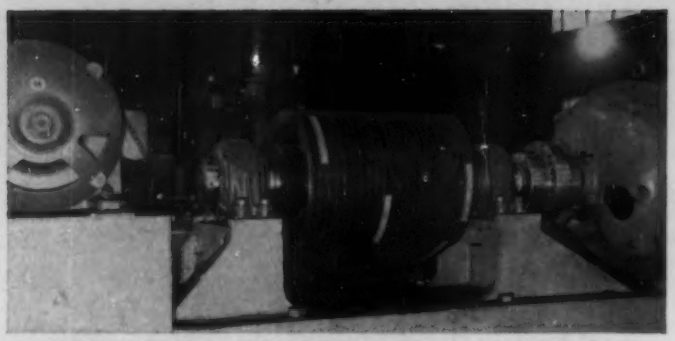

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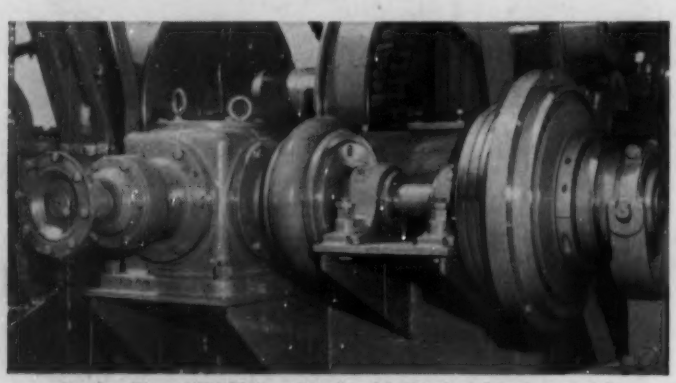
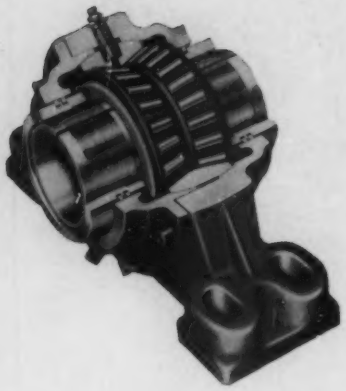


Dodge Type "E" Pillow Block with Timken bearings used on drive hookup of a rotary table.

Dodge 7" Special Duty Pillow Blocks with Timken bearings used on skip hoist bull wheel at a steel mill.



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